OCULAR PSYCHOMETRY

Ocular-psychometry
by
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DEDICATED
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Advancement of the Professional Practice
of
OPTOMETRY
for
THE PROTECTION, PERFECTION,
AND PRESERVATION
OF VISION.

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FOREWORD

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The material contained within this Treatise appeared in serial form in "The American Journal of Optometry" during the year 1928, and is reprinted through the courtesy of the editors of that publication. Here and there a few changes have been made, and a few paragraphs added to make certain chapters more valuable for reference. But, on the whole, the text is unchanged.

The reader will find the composition discoursive rather than in the usual text-book style, and will understand its vagrancies by realizing that it has been more than a year in preparation. Not a year devoted to literary crystalization of an established art; but a year of the most intensive activity and epochal developments in this branch of ophthalmic science, in which the authors have been submerged.

This volume is not intended to be the last word in orthoptic training, neither is it the first word. It represents the first amalgamation of ideas that have been growing for years in the minds of many men, devotees of many theories of visual improvement.

The introduction of Myoculator Technique has not only added immensely to the facilities of the average optometrist, but has everywhere awakened new interest in the science and practice of optometry, and has served as a common ground upon which men of widely diverse opinions could meet for the first time. The result is that a new conception of optometric service and opportunity is being born.

This volume then is a memento of the birth of the Professional Practice of Corrective Optometry.

The authors would like to make acknowledgment to all who have contributed to the preparation of this volume, but space makes that impossible. Specific acknowledgment must be made to Dr. Harry K. Fuog, whose originality produced the fundamentals of Myoculator Technique; to Dr. A. S. Cameron whose patient censoring has kept the text understandable to the practical minded; and *particularly to the six hundred Myoculator Technicians whose case reports and correspondence have furnished the clinical data and foundation of fact upon which any philosophical presentation must stand.*

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CHAPTER 1.

VISUAL FUNCTIONS.

Life is the process of continual adjustment to a changing environment. Every physical action, or mental conception is, directly or indirectly, the result of external stimulation by means of which the body is made aware of environmental change. That which we call "the mind" is the clearing house of the human system wherein the reports of environmental change, brought in by the "senses," are analyzed, and filed for future reference; and from which orders go out directing the adjustment of the body to the changes of environment.

A review of authorities discloses that "the mind" cannot be definitely located because every cell of which the body is composed seems to have a certain "intelligence" of its own. However, the brain and spiral cord is usually conceded to be the main office of the intelligence department, and the nervous system, the means of communication with other departments. Undoubtedly it is through the brain that we are aware of our bodies, and of the world about us; but we are never aware of the brain itself, or of the nervous system. We are conscious only of those things which are reported to the brain, through the nervous system.[1]

Of the special senses whose duty it is to report environmental changes to the brain, the sense of sight, though not essential to life, is undoubtedly the most important. It is estimated, eighty per cent of all we learn of the world about us is reported to the brain through the eyes, *but under normal conditions we are never conscious of our eyes, or of the fact that the physical force which we term light is acting upon the retina.*[2] If the light is too bright we are conscious of pain, or if the light is too dim we are conscious of annoyance, strain, or our inability to see; and if the eyes themselves are not functioning properly we are conscious of the various sensations commonly described as "eye strain" and headaches; but in the normal response to normal visual stimulation we are conscious only of the object in space and the mind is entirely occupied with the significance of that object relative to our own well being. To become conscious of one's eyes during the process of "seeing" the world about us is, in itself, indicative of other than normal conditions.

It is a matter of common optometric knowledge that we visually concentrate on but one object at a time, and that in any normal use of the eyes this "point of fixation" is constantly changing. The object which is imaged upon the fovea centralis is, normally, the object which engages the mind. Normally not more than three seconds, usually not more than one-fourth of a second is required for the mind

to fully interpret a motionless, unchanging macular image. Therefore the eyes must be directed from point to point almost unceasingly, and obviously, if one is not to become conscious of the eye movements themselves, and the mind is to be left free to consider the objects in space, *the movement of the eyes in normal use must be directed without conscious effort, that is, automaticity of ocular control.*

The perfectly normal pair of human eyes function as a unit so precisely that the mind is never conscious of them.[3] They move constantly throughout the normal waking day, without fatigue. Yet if the eyes be closed, they assume a position of rest, and remain practically motionless. If, while closed, the eyes are directed to the right, then to the left, then up, then down, and so on; obviously the movement is directed by thought, and it is significant that weariness soon results from such purely volitional movement. The extent of the movement is reported to the brain so that the mind becomes conscious of "the feel of the muscles," something that never occurs under normal circumstances.

Under normal circumstances the normal pair of eyes never causes awareness of diplopia, yet holding one's finger a few inches from the nose and looking beyond it will demonstrate that diplopia constantly exists. Diplopia of an object with which the mind is engaged is almost intolerable and the experimenter will experience a conscious desire to "fix" the finger binocularly during the above test.

The intolerance of diplopia is readily explained by the fact that if the mind is to correctly interpret the external world, the reports of that world brought in by the sense of sight must conform to the reports brought in by the sense of touch. If we touched but one object, though seeing two, we would be constantly confused. Normally we "feel" with one hand at a time, and are perfectly aware which hand is making the investigation. Normally we see with both eyes at the same time, and if one eye is excluded from the visual act, we are not perfectly aware which eye continues the investigation. For example, if a subject having normal eyes is asked to watch a red light in a darkened room while a ruby glass is held before one eye, and at the same time a red-free glass is placed before the other eye the subject will continue to see the red light, but the eye behind the red-free glass will be excluded from the visual act, and the subject will be unable to say with which eye he is seeing the light until he covers one eye or the other. On the other hand, patients who have anisometropia, or heterophoria, or heterotropia, frequently—almost usually—are able to say correctly which eye sees the light although both remain uncovered. The awareness of the seeing eye seems to be in proportion to the extent of the ametropia or heterophoria.

Until a child is three months of age, the eyes move more or less independently of each other,[4] coordination is not perfect until the end of the sixth year. The ability to maintain single binocular vision is acquired in each individual, just as the ability to maintain an upright position and to walk is acquired. If, during this period of develop-

ment, something interferes with its perfect completion, so that single binocular vision is not maintained automatically as it is in orthophoria, it becomes necessary for the patient to maintain single binocular vision by an effort of will comparable to the effort required to move the eyes when the lids are closed; and the patient complains of "pulling sensations," aches, pains and headaches very like the sensations experienced when rotation of the closed eyes is continued to the point of fatigue.

It is common knowledge that the greater conscious effort aroused by any muscular movement, the more awkward and tiresome that movement becomes. So, if the automatic adjustment for single binocular vision is not perfect and diplopia is frequent enough to be confusing, the patient learns to be aware of the image of one eye to the exclusion of the other, just as we are aware of one hand to the exclusion of the other; and if vision with one eye is more efficient than with the other, the inefficient eye is suppressed and gradually becomes less efficient from lack of dependence thereupon, this condition is known as amblyopia exanopsia.

Case histories reveal complete exclusion of one eye, even temporarily, during the first three or four years of life, frequently solves the diplopia problem. This solution leads the individual to develop the faculty of suppression, rather than the faculty of fusion; so that suppression leading to amblyopia becomes the cause of heterotropia or heterophoria rather than the result. In fact, Maddox states, "perfect orthophoria (by which I mean orthophoria maintained if one eye be excluded for a week) is not found in one of a thousand."[5]

Perfect development of single binocular vision is the mental acceptance of the two retinal stimulations, and if one eye is stimulated by "red" light while the other is stimulated by its compliment, "signal green" the mental conception is "whitish"—"a blending of the two to form a distinct third color." This mental fusion is something more than mere mechanical matching and is essential to comfortable vision. For, after all, we see with the mind through the eye. Furthermore, visual comfort demands that the mind be left free to consider the object "seen" without being burdened with consciousness of the organic means employed. Light from the object in space stimulates the retina. The message is conveyed to the brain. Nerve impulses travel from the brain to the muscles, so that the object is clearly imaged upon the macula. Then and normally, not until then, does consciousness awaken to record the color, form, distance and signficance of the object.

To properly understand and develop the control of ocular muscles, it is not sufficient to consider merely the muscles themselves. Neither is it sufficient to include the motor centers of the brain and nothing more. It is even more essential that the means of stimulating to motor centers be understood, for once stimulated the motor centers proceed to excite the muscles no matter whence came the stimulation.

Normal eyes provide single binocular vision without awakening consciousness; sub-normal eyes may provide single binocular vision more or less aided by consciousness; and some sub-normal eyes do not provide single binocular vision at all. To develop either of the latter to normal, will require comprehensive knowledge of the entire process involved from retinal stimulation to muscular adjustment.

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CHAPTER 2.

HISTOLOGY.

Light from an object in space falls upon the retina in consequence of some change in environment. The eyes are adjusted to better receive the light from the object in question; the head, the arms, legs and body as a whole moves to a more favorable position; the emotions (fear, pleasure, etc.) are aroused, indicating (we are told) visceral adjustments; thoughts are awakened; and, finally, the events transpiring are indelibly recorded in the archives of memory. Some of these adjustments are seemingly independent of the others. For example, your eyes may investigate a moving object just beyond this page, and revert to the type again without disturbing your trend of thought; without arousing your emotions, and without any other apparent physical movement than that of the eyes. Common experience will verify the assertions that movement of some object in space is most effective in awakening such instantaneous readjustment of the eyes, and that normal eyes shift from the original object of regard to the second unerringly, without pausing to record any of the objects lying between the first and second position. In fact, such eye movements are usually accompanied by a winking of the lids, shutting out light from objects which would otherwise lie in the path of direct vision. Again introspection will convince anyone that such ocular adjustments precede thought and awareness. We are aware that our eyes have moved, without having thought of moving them, and without being aware of the fact that they are moving during the actual adjustment.

Realizing that the retina is the tissue which receives external stimulation and starts the whole series of bodily responses, it is essential that the retina be studied with the actual facts of every day experience clearly in mind, with the aim of discovering if possible, the details of structure which constitute the "triggers" for setting off the various reflexes. (The word "reflex" is here used in its technical sense, to designate the total process taking place over an arc.)[6]

For our present purpose we may forget the ten layers of the retina memorized for graduation purposes, and consider the retina as consisting of but three layers, or units, which we can best understand by borrowing terms now so familiar to thousands of radio fans. First, the retinal detector unit consists of the rods, cones, retinal pigment and rodopsin. Second, the first stage amplifying unit consists principally of the bipolar cells. Third, the second stage amplifying unit consists of the ganglionic cells, the axon fibers of which constitute the fibers of the optic nerve.

The best understood elements of the detector unit are the rods

and cones. The rods are probably the more primitive cells. Their receiving ends appear to consist of almost infinitesimal discs so that the rod resembles a column of stacked coins. When light of any wave length within the limits of the visible spectrum falls upon or close to these discs, energy is released within the rod cell and tends to flow out of the end opposite the discs.[7]

The energy released within the cells of the body is called "nerve impulse," "nervicity," etc. All modern authorities show a tendency to accept the theory of this nerve force being a form of electricity.[8] In this discussion we shall use the term "nervicity," coined by Savage.

The cone cells are probably a higher development of the rod cells. The cone cell is more selective—that is, it responds better to certain wave lengths of light than to others, thereby making "color vision" possible. The cone cells have also developed a portion, known as the Cone Myoid (Myoid means "like a muscle") by means of which the cone thrusts its sensitive discs deeper into the pigment of the retina when exposed to strong light, withdrawing them again as the light grows dim.

At the fovea centralis, which is commonly referred to as the most sensitive portion of the retina, there are cone cells only. A little farther out, each cone is surrounded by a ring of rods. Still farther from the retina, beyond the macula, each cone is surrounded by five or six rings of rods; and so on, out to the periphery of the retina where both rods and cones are less numerous, but where the rods decidedly predominate.

The function of retinal pigment, and rodopsin is still a matter of conjecture. Most writers agree that at least part of their function is to insulate one cell from another, and to protect the rods and cones from excessive light.

From the rods and cones (1st unit) the nervicity flows to the bipolar cells in the amplifying section of the retina. (2nd unit.) There may be several rods communicating with a single rod-bipolar, but there is never more than two, and usually but one cone communicating with a single cone-bipolar. From this it becomes a logical conclusion that the intensity of the light upon the retina, and the color (wave length) of the light are the important factors in determining the strength of the nervicity stimulation to a cone-bipolar. But in the case of the rod-bipolar there is an added factor. Obviously if the area of the retina illuminated is so small that only one or two rods are stimulated to action, the nervicity delivered to the rod-bipolar will be much less than if the area of illumination were great enough to stimulate many of the several rods communicating with the one rod-bipolar; or if the point of light were moving across the retina so that one rod after another was stimulated, the rod-bipolar would receive an infinitely rapid series of charges of nervicity having as great or greater effect than if the illuminated area were large enough to cover many rod cells.

Within this amplifying section of the retina are "horizontal" cells receiving nervicity from, and probably communicating between, groups of rods and cones; and four other types of cells whose functions are not at all known, as they do not, apparently, communicate with the ganglionic cells.[9]

The second stage of amplification takes place in the ganglionic cells. Never more than two, and usually only one cone-bipolar communicates with a single cone-ganglion; so that each cone has, so to speak, a private wire to the brain. On the other hand, several rod bipolars may communicate with a single rod ganglion, so that as many as 250 rods may send their nervicity to the brain over a single optic nerve fiber.[10]

Summing up, we find the rods, by reason of their 250 to 1, relay to the brain are best suited to be the triggers for starting the train of cell activity which informs the brain of movement of objects not located in the direct line of vision. We find the cones, by reason of their "private wire" communication to the brain, best suited to start the activity which results finally in the normal "20/20" acuity of direct vision; and we understand why acuity should fall to approximately 20/100 when the image upon the retina is about 3° from the fovea, and to 20/250 at about 10° from the line of direct vision, etc., until the normal person has practically no "form" conception when the object is imaged upon the periphery of his retina.[11]

Again, the cones, by reason of the "cone myoid" are best suited to detect slight variations of light intensity; and as color perception is best where cones are most numerous,[12] all authorities agree that cones start the chain of responses resulting in color perception. Finally, as color and form perception diminish as the eye becomes "dark adapted"; while responses to movement increase, it is accepted that day vision is cone vision, while night vision is rod vision.

It will be seen that impulses from the retina to the brain reach the brain as the total nervicity produced by at least three cells. Rod or cone + bipolar + ganglion nervicity. When we realize that the energy delivered to the brain by other sensory nerves is often the output of but a single cell, we are able to understand how it is possible for the faint touch of light upon the retina to make as great an impression upon the brain as the substantial touch of matter upon the skin. The function of every nerve cell is the production of nervicity by the release of energy through combustion. Just as the production of electricity by a dry battery is a chemical process, so is the production of nervicity a chemical process, requiring the constant destruction of organic compounds, which must be replaced; and the constant accumulation of waste products, which must be eliminated. The tearing down process (katabolism) goes on constantly when the cell is being stimulated; the building up process (anabolism) is accomplished while the cell is resting. Work and rest—work and rest, is the ideal program for longevity and efficiency. Rhythmical alter-

nation between light and darkness provides that ideal program for the retinal cells.

If, however, the rhythmical alternation is so rapid that the succeeding stimulation is produced before the effects of the first have entirely disappeared the second charge is added to the first. This is the law of summation of stimulation of which more will be said in later chapters.[13]

Every optometrist is familiar with the fact that the ganglionic fibers (optic nerve fibers) from the retina of each eye divide at the optic chiasma where the fibers from the right half of each retina go to the right half of the brain, and the fibers from the left half of each retina go to the left half of the brain, while some fibers from each macula go to each half of the brain.

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[11]W. D. Zoethout—"Physiological Optics," page 337.

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CHAPTER 3.

PSYCHOLOGY OF VISION.

After the separation of the fibers in the optic nerve at the optic chiasma, so that the fibers from the right half of each retina go to the right half of the brain, and the fibers from the left half of each retina go to the left half of the brain, the fibers are then traceable to three portions of the brain. One group of fibers end in the Internal Geniculate bodies;[14] but upon tracing these fibers back, it is found that they do not continue to the retina at all. They travel along with the optic fibers to the chiasma and continue around to the Internal Geniculate body in the opposite lobe of the brain. Their function, logically, seems to be to acquaint one-half of the brain with the visual experiences of the other half. These fibers constitute "Gudden's Commissure."

A second group of fibers is traceable to the Pulvinar of the Optic Thalamus, and to the External Geniculate bodies. It is suggested by some investigators that the fibers to the Pulvinar deliver the impulses which give rise to emotional responses to retinal stimulation, but, for present, purely practical purposes, the External Geniculate and Pulvinar bodies may be considered as one. Here fibers from the retina end. There is no direct connection with any other nerve fibers, but almost in contact with the ends of the fibers from the retina are nerve cells which carry impulses from these bodies to the occipital cortex.

The third group of retinal fibers, comparatively few in number, but observably larger in size, end in the Superior Quadrigeminal bodies. The nervicity discharged by them is relayed by nerve fibers which lead from the Quadrigeminal bodies to the nucleus of the third, fourth, and sixth motor nerves. The nervicity from this group never reaches the cortex at all.

The nerve fibers from the retina ending in the Geniculate bodies are called the "visual fibers," for reasons that will be apparent later. Nerve fibers which relay nervicity from the Geniculate bodies to the cortex are called the "optic radiations." The fibers from the retina to the Superior Quadrigeminal bodies have been called the "pupillary" fibers, which is obviously not completely descriptive as nervicity from them is relayed to the fourth and sixth motor nuclei as well as to the third nerve nucleus. Zoethout suggests that impulses over these fibers are responsible for all the protective reflex actions such as movements of the eyes, eyelids, head, and even the body in dodging rapidly approaching objects. Every person has had the experience of "dodging" a flying object without having been aware

of "seeing" it. Observation of anyone's eyes will convince the observer that most eye movements precede visual conception, or thought, of the object which attracted the eye. This relay from the retina direct to the motion centers is the most logically acceptable mechanism for the performance of such automatic actions.

The occipital cortex may be described as a tangle of nerve cells, or brain cells, pyramidal in shape, the fibers of which are not insulated from each other. The brain cells of the occipital cortex are constantly being stimulated by nervicity delivered through all the sensory nerves; and that nervicity, as well as the nervicity produced by the brain cells themselves, is free to travel to any part of the cortex. One's first thought is that dreadful confusion must exist in the cortex; and in some brains that is true—(hysteria) but in the normal brain in some manner, not at all well understood, the nervicity is definitely directed through the cortex.[15] George Crile, M. D., Senior Consultant in Surgical Research, A. E. F., 1917-1918, Professor of Surgery, School of Medicine, Western Reserve University, Visiting Surgeon to the Lakeside Hospital, Cleveland, Ohio, U. S. A., in "A Physical Interpretation of Shock, Exhaustion, and Restoration," suggests that it is the function of the white matter to direct the flow of nervicity through the brain; but whatever the instrument employed, the ability of the individual to direct the flow of nervicity through the portions of the brain such as the Geniculate bodies, the Quadrigeminal bodies, and the cortex, is called "will power," "volition," "thought," etc.

This fact has been well established by common experience: That when nervicity has once been directed along a certain path in the labyrinth of brain fibers in the Cortex, Geniculate, or Quadrigeminal bodies, it follows the same path more readily the second time; and eventually, after much repetition, or under circumstances to be discussed in the next chapter, it follows the path originally selected by circumstance or will power without the necessity for "thought" or "attention." We then say that a habit has been formed, or that we have "learned" to do something. The prompt, direct precise reaction to an external or retinal stimulation without the guidance of attention or thought is called an "automatism." Some such reactions have become so well established throughout so many thousands of successive generations that they are now present at birth, and do not have to be acquired by the individual. These are called "primary reflexes," or "instinctive reactions."

(Note: Inasmuch as the visual processes are all located within the cranium, nothing is said here of the spinal column. If the readers' thoughts turn to reactions to other than visual stimulation, or to bodily responses to visual stimulation, the spinal cord is as worthy of consideration as the brain.)

Perhaps the "mind" resides principally within the cortex; and it seems to be the home of "reason." Attempts to localize "brain

centers" such as "combativeness," "idealism," "amativeness," etc., have always been popular, but few of these theories have been advanced by men who have extensively studied the brain itself. Knight Dunlap discourages the use of the term "brain centers," except in the sense that sensory impulses can be traced to definite portions of the cortex, and motor impulses, going out of the brain can be traced back to definite nuclei. The twelve centers assumed by Savage to exist cannot be demonstrated or located; and even the "color centers," "form centers," etc., are more a matter of convenience in discussion than of fact. However, it has been definitely shown that along the calcarine fissure of the occipital cortex certain small areas are so closely related to the retina that destruction of a certain portion of the brain at that point results in a definite scotoma of a certain portion of the retina; and that electrical stimulation of these areas will cause the eyes to rotate to the right or left, depending upon the area stimulated. Furthermore, the memory of things seen is lost if portions of the brain near the calcarine fissure are destroyed; so we may safely assume that the retina has a point for point representation somewhere near the calcarine fissure which enables us to interpret a given pattern of retinal stimulation in terms of visualized, or mental pictures of objects in space; and that this picture may be reproduced to an extent depending upon its original vividness and the individual's practice, without repetition of the original stimulation. Furthermore, it may be assumed that it is from this area that nervicity is directed to the motor "centers" (nuclei of the third, fourth and sixth nerves) when "thought," "attention," or "volition" directs the eyes toward a certain point in the visible world.

Nervicity generated within the brain, or cortex particularly, flows out along the fibers of the motor nerves; any or all of them, whether they lead to visceral muscles, skeletal muscles, or to the glands. The path followed depending upon the convenience of the outlet to the most active brain area; the developed paths of automatism; and the influence of "thought."

The influence of "will" is probably brought to bear in those areas where one nerve fiber ends and another begins. These "open contacts" between the axon (out-put end) of one nerve cell, and the dentrons (in-take ends) of other nerve cells are called synapses; so it is that establishing automatisms, acquiring habits of action or thought, or learning to do anything, is often referred to as "synaptic training." But after the nervicity reaches one of the outlets, such as the motor nuclei it can no longer be influenced by the "mind." It flows like an electric current to the point where it is "grounded" in muscle or gland.

The outlets to the muscles of the eye are the third, fourth, and sixth motor nuclei. It must not be assumed that a nerve, the fourth for example, consists of a single fiber. On the contrary, it, like the optic nerve, is more like a cable—a bundle of many fibers, each carrying nervicity from the nucleus to the particular muscle cell it

is intended to serve. Furthermore, each of the motor nerves of the eye contain fibers that carry nervicity from the muscle cell back to the brain so that, on occasion, we become aware of a muscle "sense." Knight Dunlap observes that these returning afferent fibers are probably responsible for the exact coordination of the ocular muscles through the many fibers communicating between the third, fourth, and sixth nuclei, and the members of each pair. In other words, it is probably that the nervicity returning from the contracted right external rectus finds its way directly to the right internal rectus and aids in the extension of that muscle, and to all the other muscles, for that matter, aiding in their nice adjustment to the new point of fixation; and if the effort of contraction of a given muscle be abnormally great, the returning nervicity generated may be sufficient to make the individual "aware" of the contraction; yet we are never "aware" of our eye muscles under normal circumstances.

Neither must it be assumed that the nucleus of the third cranial nerve, which serves seven muscles of each eye, is a single brain area. The nucleus of the third nerve is strung out along the floor of the fourth ventrical to such an extent that seven more or less distinct areas, corresponding to the seven muscles served, have been definitely located. [16] One may safely assume the several muscles of the eyes to be controlled each by a definite group of brain cells which, like the keys of an organ, are capable of almost infinite combinations when played upon by the nervicity flowing out of the Cortex, the Quadrigeminal bodies, and back from the muscles themselves; and like the organ keys, they may be so played upon that pleasing harmony, or painful discords result.

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SYNAPTIC AREAS, ORTHOPHORIA AND "DUCTIONS."

CHAPTER 4.

A. V. Hill,[17] in his "Muscular Movement in Man," described the human body as an intricate machine played upon by external forces. Nowhere does it seem more true that external forces determine muscular movement than in observing the activity of the ocular muscles manifest by the natural movements of the human eye. Normal eyes seem always to move as of their own accord without waiting for instruction from the brain behind them. Any sudden unexpected change within the field of indirect vision will instantly attract the normal eye; yet the image of the object toward which the eyes are turned is not "seen"—that is, there can be no accurate conception of form, size or color of the object until the image of it is within at least 10° of the centralis.[18] In fact, the logical purpose in turning the eyes to fixate the object is to make "seeing it" possible. The movement precedes conception of the exciting object.

Such prior-perceptual movements suggest that they are induced by impulses which travel from the peripheral portions of the retina, over the fibers of the optic nerve, through the quadrigeminal bodies, direct to the motor centers; thence to the ocular muscles. This series of neurons may therefore be considered a prior-perceptual synaptic path, and the line of least resistance for motion exciting impulses.

If one of a pair of normal adult eyes be covered with an opaque card, an observer, watching the eye behind the card will discover that it faithfully executes every movement performed by the companion eye. Prior-preceptual surely, because the excluded eye is receiving no external stimulus and perception is impossible.. Yet the eye performs in every respect as if it were stimulated, and in suggesting the synaptic path which the directing impulse probably follows, we logically favor the afferent fibers of the motor nerves and the intricate system of commissural fibers communicating between the motor nuclei as offering the most direct route and the line of least resistance.[19]

In both of the above instances, prior-perceptual synaptic paths are selected which reach the motor nuclei before they relay to the visual area of the cortex, for it is in the calcerine area of the cortex that the visual picture is formed, and "the picture" plays no part in the movements described. However, there are eye movements which do depend upon the visual picture, or perception. These, and the foregoing prior-perceptual movements may be observed in the following experiment:

Instruct a person with normal eyes to fix upon a distant stationary object or small light. Suddenly interpose a 5 to 10 diopter

prism base-in before the right eye, and closely observe the resultant movements of both eyes, especially the left.[20]

The sudden apparent movement of the object of regard will cause the right eye to move toward the apex of the prism; at the same time the left eye will move in the same direction although no movement of the object has been directly recorded upon the left retina. These movements are prior-perceptual.

Then, as the subject becomes aware of diplopia (perception of form) both eyes become involved in a series of rapid, short movements until abduction ("out" duction) satisfies the demand of "fusion." This last adjustment or movement comes only after the subject is aware of diplopia, and is post-perceptual; is never required of normal eyes under normal circumstances.

No matter how often the experiment be repeated; no matter how expert the subject becomes in "fusing the prism" employed, even if he "fuses" so quickly that he is not consciously aware of momentary diplopia, a keen observer will always be able to detect the slight, lightning quick twitch of the left eye produced by the prior-perceptual impulse before it is over-ridden by the more powerful, cumbersome post-perceptual impulses which have followed the more intricate path.

The property of each neuron to amplify the impulse it relays[21] and a longer synaptic path for the post-perceptual "duction" movement explains its ability to overthrow the relative position established by the prior-perceptual impulses. The synaptic path would seem to be from the maculae, over the visual fibers, through the external geniculate bodies, to the calcerine fissure; there, unquestionably, memory of previous experiences of touch or sight identifies the sensation as "seeing double," then the impulse, greatly amplified, is returned to the quadriginimal bodies and finally relayed to the motor nuclei, thence to the muscles.

Constant repetition of a given experience dulls consciousness of that experience. Objects that have become familiar are seen day after day, but we are not consciously aware of them until some change in or about them takes place. So it is that although the "ductions" depend absolutely upon awareness of diplopia, constant repetition of experiencing diplopia dulls consciousness, and only the twitch of the eye under the prism experiment, the cover test, and symptoms of nervousness at times, betrays its presence in cases where heterophoria demands constant, abnormal, "duction" effort.

Nature in the development of normal human eyes trains them first of all, independently, to investigate moving objects; then to coordinate and follow each other. The first function appears at the age of five weeks, the second at about the end of the third month; being perfected usually by the end of the sixth month when binocular fixation is observed in the average normal child.

At about the age of twelve months, the calcerine area begins

to function in that the child has learned the significance of many objects, and fusion makes its appearance.

The perfect development of these prior-perceptual functions results in that condition known as "orthophoria."

It is significant that in order to determine the presence or absence of esophoria, exophoria, hyperphoria, hypophoria, or cyclophoria, it is first necessary to make fusion impossible. It is common practice to employ a maddox rod before one eye and a red glass before the other; a prism "base up" before one eye, and "base down" before the other; or the cover test—i.e., to hold an opaque card before one eye and observe the relative position to the fixing eye. It must therefore be conceded that orthophoria and its development does not depend on fusion and fusion has nothing to do with it.

Orthophoria is the demonstration of perfect fixation efficiency of each eye; and equal experience of each eye in responding to external stimulations exciting fixation. That is perfect prior-perceptual brain paths.

Optometric experience teaches that patients who have orthophoria are usually comfortable; and that those who have heterophorias of significant amounts are not comfortable, unless, as in rare cases, some other fault balances the tonal fault. For example, the hyperope of approximately one diopter with 4 to 6 prism diopter of exophoria, is usually comfortable, and the profession of Optometry in considering its duty to the eyes of humanity should endeavor to eliminate heterophorias rather than to offset them with ductions, or bolster them up with prism crutches.

To accomplish this, every effort should be made to duplicate the methods employed by nature—that is, to train each eye in the precise instantaneous fixation of moving objects in a manner calculated to employ the prior-perceptual synaptic routes as much as possible, and the post-perceptual route as little as possible.

Furthermore, inasmuch as the afferent fibers of the motor nerves are probably the most important nerve paths in the maintenance of concomitance and orthophoria, it is advisable to seek means of developing those paths to the greatest possible extent.

Inasmuch as the afferent impulse originates in the muscle cell, it is logical to assume that the more active the muscle cell, the stronger the impulse will be. It is, therefore, a logical conclusion that having the extrinsic muscles as naturally active as possible offers the best opportunity for perfect establishment of orthophoria. Not only is this a logical deduction but it is the experience of those who have put such principles into practice.

In some instances, Optomertists employing no other means than merely causing great natural movement and activity of the extrinsic muscles, by having the patient follow moving objects of various kinds, have succeeded in eliminating considerable amounts of heterophoria. In other instances, the orthodox prism exercises have been

employed (which usually results in building "duction" powers with little or no immediate effect on the existing heterophoria),[22] and by substituting a rhythmically moving fixation object for the orthodox stationary "muscle light"; thereby causing great, natural activity of the extrinsic muscles they have been able to change esophoria, hyperphoria, exophoria, etc., to orthophoria within a span of days. More refined methods have corrected heterophorias in a much shorter time.

The patient who is unfortunate enough to have an heterophoria must employ that unnatural function known as "duction power" to maintain single binocular vision to avoid crossed-eyes.

Suppose then, an individual, through some circumstance or environment (an error of refraction in one eye only, or the temporary interference of the vision of one eye through illness or accident) developed greater efficiency of prior-perceptual fixation in one eye than in the other. A sudden change in his visual environment would cause each eye to move toward fixation of the object, but because of inefficiency, the one eye would lag and be some distance from its goal by the time impulses from both eyes reached the calcerine area via the visual fibers. Impulses from this area would then be sent to the motor centers and the further adjustment toward binocular fixation would, from then on, be governed by the post-perceptual "ductions." After a time, the prior-perceptual adjustment being constantly "picked up" at a given position would leave the prior-perceptual inexperienced beyond that point, so that lacking stimulation of the visual area of the cortex to guide them (as under the conditions imposed by a "phoria test"), the prior-perceptual would carry the eye toward fixation only so far as they had been carried in daily experience, and our patient would be recorded as having heterophoria.

It is true that diplopia would be experienced in the above case but it is also true that our consciousness of conditions experienced becomes dulled by repetition. Comparatively few patients with muscular imbalances, complain of diplopia even though many are found whose eyes visibly deviate at times. The eyes of such patients exhibit their fault whenever fusion is made impossible or when devices are employed which disguise diplopia.

Duction powers may be described as the ability to achieve or maintain binocular fixation to avoid diplopia. Obviously the patient with, for example, esophoria, will be made more comfortable by an increased ability of abduction (out duction) but every Optometrist finds many patients with ample duction power who still complain of discomfort, especially when fatigued, worried or annoyed. This is not surprising when we observe the indisputable fact that out duction, induction (if that be defined as turning the eyes inward without accommodation) hyper (up) or deorsum (down) duction, are never required of normal eyes under normal circumstances. If, as in the natural order of things, the prior-perceptual binocular fixation is per-

fectly developed, the visual fibers will deliver their impulse from the macula of each eye at exactly the same instant, and the impulses from the cortex to the motor centers will never be required except to hold the eyes steadily fixed upon the object of regard.

When this impulse from the awareness of diplopia to the motor centers is developed, as it is in prism "exercise" beyond the normal requirement, it is undoubtedly better than seeing double; but unquestionably less efficient than normal orthophoria. Developing super-normal duction powers to offset heterophoria is merely developing a super-normal ability to offset an abnormal condition. "Nature tends towards the normal," is a maxim of all who observe her works, so it is not surprising that patients given such relief find it a temporary measure; whereas, those who are restored to normal orthophoria find themselves permanently relieved.

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CHAPTER 5.

CORRECTIVE PRINCIPLES.

This chapter is not intended to be a history of Oculo-Calisthenics. In order to conserve space, all methods that have been and are now employed in attempts to relieve Asthenopia, Asthenic disturbances and the various discomforts attending anomalies of the ocular muscles are herein grouped under the following broad classifications and discussed in the order given:

1—Occlusion
2—Prisms
3—Surgery
4—"Duction" Building
5—"Vergence" Building
6—Physiologic Training

The first group (Occlusion) is intended to include all measures taken to suppress, supplant, or avoid one or more natural normal functions, which if exercised tends to aggravate the abnormal condition.

Several examples are: "Fogging out" one eye with plus spheres; or ignoring its refractive error in cases of aniso— or antimetropia. Prescribing "frosted" lens for the squinting eye in cases of Heterotropia where the diplopia-sense is retained. "Crowding on the plus" until vision is blurred in cases of Esophoria or Esotropia. The use of atropine in both eyes in like cases. The use of cycloplegia (atropine) so that one eye is used for distance and the other for near. The fitting of bifocals prior to presbyopia to avoid accommodation inducing excessive convergence.

Obviously the philosophy supporting the above practice is that it is better to have a comfortable usable part than an uncomfortable whole; which is admittedly permissible as a last resort, but not to be considered as tending toward correction of the abnormal conditions the effects of which they seek to avoid. In fact, permanent improvement of the primary difficulty we believe is so rare under such treatment that one is justified in the assumption that improvement, when it occurs, is in spite of rather than because of the treatment.

The second group (Prisms) includes as well as the prism prescription for continuous use, antagnostic prisms which are generally conceded to be impractical in practice; prisms for reading only; and prism "segments" sometimes employed in cases of antimetropia. There are cases, particularly in aphakia of one eye, when the use of prism "segments" is unquestionably good practice; but inasmuch as resort to prism correction is in most cases a surrender to the existing heterophoria and not an attempt at restoration of natural orthophoria,

we therefore believe prism corrections on the whole must be considered only on par with, or as crutches.

Crutches are at times justifiable as a temporary measure in bringing relief to tortured organs. In the strict ocular sense, prism correction as a temporary means of providing and developing "fusion" are to be commended; but the permanent prism correction is rarely justified and it is almost as rarely comfortable and acceptable to the patient. A great many (one may safely say almost all) cases of heterophoria are variable in degree—that is, the amount of the error is subject to variation according to the hour of the day, the patient's physical or mental state and the direction in which both eyes are turned as the patient looks right, left, up or down, far or near.[23] Prisms, however, are of necessity made of inflexible glass. So, not only because they are a poor substitute for a physiologic correction of heterophoria, but also because of the almost infinite complications they invoke, it is indeed fortunate that modern well informed, conscientious and painstaking optometrists must resort to the prism Rx but very, very seldom.

The third group (Surgery) is intended to be broad enough to include; besides cutting and ligating (which are resorted to chiefly for aesthetic reasons only, and therefore do not require discussion herein) those corrective measures involving manipulation of the eyeball with the fingers, "spoons," "massage cups" and other mechanical devices.[24] The philosophy of such methods are based on the assumption that "adhesions" prevent the eyes from enjoying full, effortless rotation; or that the difficulty (including sometimes errors of refraction) is the result of lymphatic disturbances.[25] Unquestionably there are cases in which tendinous adhesions are at least, in part, responsible for heterophoria and heterotropia, and other cases in which ocular lymph production, circulation, and drainage should be improved to assure normal conditions, but unfortunately, neither surgical nor manipulative treatments of the eye are complete in themselves. Any disruption or disturbance of the delicate ocular or extra ocular tissue tends to leave the tissue decidedly subnormal in tonicity or natural resilience, so that Oculo-Calisthenics—strictly within the field of Optometric practice—should, we believe, follow all such treatment of the eye, and in the strictest sense, should both precede and follow all forms of ocular surgery.

The fourth group (Duction Building) includes all forms of the so-called "prism exercises," whether with the rotary prism, trial case prisms, the stereoscope, prism bar, or the jump or shock system. This group should even include the Amblyoscope for the principle in all is essentially the same.

The philosophy upon which this technique is founded is, that "fusion is the supreme ruler." It is true that such methods are exceedingly valuable where the purely psychological function, the desire for single *binocular* vision, is subnormal, but it is contrary to common experience as well as our laboratory observations to assume that poor

fusion is entirely to blame for *all*—or even in a sense *any* "muscle imbalances."

Fusion is to blame for the *discomforts,* headaches, nervousness, etc., attending heterophoria, certainly; because when there is no fusion, as in constant strabismus, there is no discomfort.

The first step in determining the presence or absence of esophoria, exophoria, hyperophoria, hypophoria or cyclophoria, is to introduce a maddox rod; a maddox double prism; opposed-base prism, or some means of providing complete dissociation, thereby *making fusion impossible!*

We believe it is obvious therefore that *fusion* has nothing to do with the existence of orthophoria, especially when we consider that in the natural development of a normal child "fusion" is the last visual faculty to make an appearance.[26]

The normal function of "fusion" is to interpret the light stimulus of two retinae so that the visual awareness agrees with conception through the sense of touch, etc., and "fusion" is employed to direct *adjustment of the ocular muscles only when some more primitive faculty is other than normal.*

Without fusion's demand for single binocular vision which calls the "duction" powers into action, heterophoria becomes unsightly, but nevertheless a quite comfortable heterotropia. When fusion demands constant use of the "duction" powers, which are never required of normal eyes under normal circumstances, heterotropia becomes more sightly, but less comfortable heterophoria.

"Exercises" and prism training designed to develop fusion; duction control of the ocular muscles to unnatural extremes for the purpose of "overcoming" or "offsetting" abnormal heterophoria or heterotropia, are as truly substitutes for real natural orthophoria, as are prism corrections; and we believe not more often permanently acceptable.

"Nature tends toward the normal" so that the super-normal, recently acquired or developed "duction" powers gradually recede to normal, leaving the original imbalance, usually about as they were before training began.

The fifth group ("Vergence" Building) embrace all forms of ocular exercise designed to induce concomitant movement of both eyes in the same direction. Dexter-vergence (both to the right); Sinister-vergence (both to the left); Supra-vergence (both up); Deorsum-vergence (both down); and Convergence(both inward).

It would also include methods frequently advocated by laymen. The underlying philosophy being that all ocular muscle imbalances, and eye discomforts, (some writers even include errors of refraction) are physical disturbances and deterioration resulting from physiologic disuse or abuse; and that relief and correction follow calisthenical activity regardless of how induced. At first glance the philosophy

strikes one in either of two ways: As utterly absurd because of its extreme simplicity, or as perfectly reasonable because until modern times, and in each individual until school-age, the human eye is a constantly moving organ, whereas, modern civilization with its printed pages, arts and crafts and "machine production" *demands for the first time in animal history* constant fixation and relative motionlessness for continuous hours;[27] thereby depriving the human eye of its inalienable right—*the constant motion for which it is ideally constructed and muscled.*

Stasis being the one extreme, and frenzied activity in modern traffic, the opposite extreme. The "Happy Medium"—the constantly roving gaze being the "Lost Art."

That certain, very favorable results, have frequently followed such methods cannot be intelligently denied, neither can it be successfully disputed that these methods fall far short of the ideal, and often fail in a manner inexplicable by the lay "enthusiasts."

The good results are readily and soundly explainable (although not by the "originators" of the several most widely advertised "systems,") by considering that normal, full flexing of the extrinsic ocular muscles tends to release minor adhesions (if such have formed), stimulates normal lymph production, circulation and drainage, and normal circulation of blood; thereby tending to restore the orbital contents to normal physical and physiological well being.

The failures of such methods we believe are readily understood when one analyzes them sufficiently to discover *that every such "lay" "system" requires that conscious thought must precede and direct the ocular movement, whereas in normal use our eyes move before we think,* and even before we become *visually aware* of the object in space the light from which provides the exciting stimulus.

The sixth group ("Physiologic" Training) is a great step in advance of the previous groups in that it provides *some moving object for the eye to follow,* thus awakening direct ocular activity in a more natural manner. That is, the calisthenical movement is excited by a moving image upon the retina, involving the complete normal reflex arc from retinal stimulation to the brain and back to the muscles.

Methods included within this group have not been widely advocated, but have nevertheless been extensively employed and with commendable results. There are two reasons why such methods have been practiced clandestinely and shamefacedly: First, because the means employed were so ridiculously cheap or crude—a pencil, a retinoscope or ophthalmoscope light with the "head" removed, or some "home made" contraption. Secondly, because results were so little superior to the results of "systems" already adopted by charlatans that the more ethical man feared to face the ridicule and criticism awakened both by the equipment employed and by the inalienable human trait—particularly characteristic of the "professional" mind—

to ridicule and decry anything new and near to his practice, especially if devoid of intricate details or complicated technique.

Results failed to surpass markedly those of similar methods because the technique lacked (a) confident introduction and application; (b) appropriate rather than impromptu appliances; and (c) *monotonous, mechanical rhythm.*

To accomplish the physiological results aimed for by all "vergence" building methods, perfect rhythm is—with few exceptions—absolutely essential.

Every army drill master and every specialist in physical training whose methods have met with success recognized the necessity for rhythm as evidenced by the universal employment of the musical accompaniment to physical training.

An ideal optometric technique of Oculo-Calisthenics should embody the best principles of everyone of the foregoing six; being a composite of them all, save the third (surgical methods). It should, however, go further and embrace means of determination (diagnosis) in addition to the regulation optometric examination for the purpose of refraction alone; so that Oculo-Calisthenics would not be recommended in the presence of conditions precluding satisfactory results.

In short, we believe the ideal technique designed to relieve ocular discomfort and to provide natural, normal orthophoria and physiologic function should include the following features:

(1) Means to disclose and demonstrate to the patient any abnormalities of ocular coordination.

(2) Means of discovering faults in the primitive functions of fixation and rotation, both monocular and binocular.

(3) Means of demonstrating the effect of "vergence" positions on binocular relations (both far and near).

(4) Means of qualifying and "grading" fusion.

(5) Means of measuring color, form, and motion perception fields.

(6) Means of measuring indirect visual acuity for comparison to direct acuity.

(7) Means of producing complete dissociation for both determinative and corrective procedure.

(8) Means of commanding attention of either eye, regardless of rate or time of alternation adopted by patient, and regardless of vergence position; and of commanding attention of both eyes when required.

(9) A great variety of conspicuous fixation targets, each of which may be moved at will into any desired position before the patient, leading the patient's eye, or eyes, through every possible movement.

(10) All movements of targets to be accomplished mechan-

ically with a minimum of attention and mechanical knowledge on the part of the optometrist.

(11) A correct systematic procedure whereby Nature's plan of visual development can be carried through to the conclusion, rather than the development of unnatural power to "offset" subnormal natural functions.

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CHAPTER 6.

MYOLOGY.

Before attempting discussion of either probable results anticipated from, or the explanation of, results already demonstrated through, Oculo-calisthenics, it is necessary that our understanding of the structures involved be clear in mind. For that reason this chapter will briefly review subjects with which the reader is undoubtedly already familiar, from the practical and experienced—rather than the student—viewpoint.

The first thought is, naturally, of the muscle structure. The muscles of the eye are among the "reddest" muscles of the human body. More like the muscles of the rabbit than any of the others. Hill[28] classes them with the muscles of respiration and mastication. Eye muscles are primarily intended for constant flexing. This together with the fact that the eyeball is so well "lubricated" and "mounted" in the folds of connective tissue and orbital fat that it is a practically frictionless "ball bearing," would indicate that Nature intended the eyeball to be in practically continual motion; and it is obvious that eyes of primitive man, and even the majority of civilized men, excepting within the last few generations, were in constant motion; the gaze roving constantly from one extreme of the visible field to another. The fixed gaze and hours of concentration upon one definite point, or a printed page, are products of contemporaneous civilization, and are as yet "new" visual requirements.

Further examination of the muscles discloses that each one consists of numerous long slender bundles of fibrils wrapped up in connective tissue, and between these smaller bundles, inbedded in the connective tissue lie the veins and arteries which supply nourishment to the muscles themselves. Enclosed in the tendinous capsule surrounding the muscle are the six to eight "muscular anterior" arteries which supply the ciliary process and muscle of accommodation of each eye.

It is common knowledge that when a muscle of the arm is constricted or tensed, it becomes more resistant to the pressure of an exploring finger, so it is readily understood that when the extrinsic ocular muscles are constricted they likewise become "hard" and the bundles of muscle fibers press against the veins and arteries lying between them so that circulation is considerably inhibited during taxation of the muscles. When the muscle is again relaxed, the blood is permitted to flow more freely, so that taxation followed immediately by relaxation and rhythmically repeated (similar to the principle employed in filling an "eye dropper") tends to increase cir-

culation so the tissues involved will receive increased nourishment commensurate with the increased work.

It is well agreed by physiologists that no blood directly enters any cell of the body but that "the blood feeds the lymph and the lymph feeds the cell" and that every living cell is bathed in lymph.

Lymph is a colorless fluid produced by the arterial blood which, upon chemical analysis varies according to the tissue in which it is found.[29]

Very little has been written on the subject of Lymph but Millard[30] makes it clear that lymph having bathed the cell in fresh nourishment, and having absorbed the products of catabolism and synthesis, passes from the tissue through lymph spaces, thence through a chain of "nodes" or small vessels communicating each to the next through a small valvular opening, finally pouring the toxin laden lymph back into the blood stream of the veins. However, a great portion of the lymph, particularly from the eyes, is not emptied directly into the veins, but is carried through the lymphatics, down the neck to the clavicle vein. Dr. Glenn S. Moore states:

"We have a triple lymphatic drainage from the eye by way of first, the eyelid, through the buccal and submaxillary lymph glands of the head to the superficial lymph glands of the neck. Secondly, this drainage is by way of the anterior lymph channels of the eyeball (canal of Schlemm and spaces of Fontana and anterior posterior chambers) all draining to the internal maxillary lymph glands. The third avenue of drainage is by way of the posterior channels of the eyeball (Hyaloid canal, supra and infra-vaginal lymph spaces and perichoroid lymph space) all draining to the subdural and subarachnoid spaces of the brain."

The lymphatics are not supplied with a vaso-motor system as are the veins and arteries, but depend largely upon mechanical action to maintain circulation; therefore, the natural constant movement of the eyeball is of great importance in removing the toxin laden lymph from the ocular tissues.

The lymph spaces of the eye are too numerous to individually mention in an article of this length, but they are found between layers of every tunic, between the tunics, in the layers of the optic nerve, and between tendinous capsule and whatever it surrounds.

The three humors of the eye answer to the description of lymph and it is not too much to expect in the not distant future, appreciable strides toward the elimination of errors of refraction and even the prevention of presbyopia and cataract through careful study and a deeper knowledge of the lymph drainage of the eyes. More immediate results, however, can be expected in comfort and efficiency of the ocular muscles through lymph drainage induced through proper calisthenical exercises of the eyes.

Each muscle cell is, in itself, a complete muscle in that the action

of the muscle as a whole is but the united effort of the individual cells. Each muscle cell consists of a little sac, known as a "sarcamere" containing a fluid substance usually called the "contractile fluid." When stained with hematoxylin (logwood acid) the contractile fluid is found to contain two elements, one of which has an affinity for the stain, while the other has not. Dunlap[31] has called one type "anisotropic" and the other "isotropic."

The extrinsic muscles stain striped because the anisotropic and isotropic elements are found in distinct layers. The intrinsic muscles however on the other hand, stain plain, because these two elements are not clearly defined but mixed; therefore, the stain is taken on as a whole.

When the muscle is "resting" or reacting to an inhibitory nerve impulse, the isotropic and anisotropic elements seem to repell each other, making the cells long and slender. Under the influence of a mandatory impulse, the elements of the contractile fluid seem to attract each other, tending to produce a spherical shape to the sarcamere, just as all bodies tend to assume a spherical form when the constituent elements exert a mutual attraction.

Whether extended or contracted, there is no change in the total volume of the muscle cell. The change is of shape only, so that as a muscle "swells" during constriction, it becomes proportionately shorter, thereby performing the "work" for which it is intended.

Any change, especially movement, is a demonstration of energy released. In this mechanical age, it is natural for us to compare muscular activity to the combustion engine. Combustion (oxidation) does actually take place within the muscle cell, but the process is somewhat of a surprise to the mind filled with automotive knowledge.

Hill[32] points out that glycogen (muscle sugar) is the fuel supplying the energy for muscular activity. When the nerve impulse is discharged into the muscle cell, the glycogen breaks up into lactic acid, constriction occurs immediately in a sort of wave traveling away from the point of stimulation; and *the individual cell shortens to the limit of its ability* or not at all, according to the favored "all or none theory."

If the entire muscle does not contract to its fullest extent, it is because the impulse is not discharged into every cell, the number of cells acting being in proportion to the amount of work to be accomplished, and the tendency of the inactive cells to offer resistance rather than aid.

When the mandatory impulse is suspended the constricted cells are relaxed and the circulatory system supplies fresh oxygen in the presence of which most of the lactic acid returns to glycogen; but some of it is "consumed" forming carbonic acid gas, which is promptly absorbed and carried away. But suppose the mandatory impulse is maintained for long periods, with insufficient or no intervals of re-

laxation; circulation would thereby be inhibited by pressure and lymph drainage likewise retarded.

Insufficient oxygen results in an overproduction of lactic acid; inefficient drainage results in accumulation of lactic acid and carbonic acid gas. The latter tends to imprison the impulse—that is, to keep the cell constricted, and the result is termed "cramp," manifest in certain cases of esophoria and of "latent hyperopia" or "pseudo-myopia."

The former, lactic acid excess, has much the same effect upon the contractile fluid as it has upon milk.

As the lactic acid accumulates within the muscle cell, the contractile substance loses its fluidity (the viscosity increases) and the cells affected offer greater resistance to the effort of the other cells of the muscle, so the muscle becomes sluggish in action, "stiffness" and "soreness" is soon experienced.

The discomfort of the ocular muscles are usually described as "eye strain headaches." Sluggishness of the ocular intrinsics is probably responsible for much premature presbyopia. Sluggishness of one or more of the ocular extrinsics may account for much eso-, exo-, hyper-phoria and so on, especially in those frequently discovered (when sought) cases wherein the error changes in kind or degree as both eyes are turned to the right, or to the left, or up or down.

Inefficiency of the ocular extrinsics, or of any group or "team" may frequently and easily be discovered by observing the patient's inability to maintain constant precise fixation of an object moving at an absolutely unwavering pace through a mathematically exact pattern or path, or by other simple means. Although the human eye is obviously a mobile organ, mounted and muscled for effortless, instant, accurate movement, and so constructed that almost constant rotation is essential to its well being and continued efficiency, and in spite of the fact that the eyes of man have enjoyed the faculty of rotation through an angle of approximately 40° in any direction for countless centuries, great numbers of "refractionists" continue to examine and treat human eyes as if they were rigidly fixed in the forward looking position and incapable of conjugate movements in all directions—laterally and vertically as well as in convergence.

During the rigid fixation of a motionless object, the extrinsic ocular muscles are tensed as the arm muscles would be if the fingers were held pointed at the same target. During the first few moments the fixation is maintained with little or no conscious effort, but shortly the sensation of "fatigue" appears; then, if the effort be sustained beyond the "fatigue" point, "strain" is experienced which frequently has an aftermath of nervousness and aversion to the work requiring such fixation and discomfort.

The explanation of "fatigue" is, in addition to the foregoing outline of the effects of excessive sarcolactic acid, to be found in con-

sidering the attachment of the nerve fiber to the muscle fiber, and the effect of lactic acid accumulations at the point of contact.

The nerve fibers are attached to the cells of the intrinsic ocular muscles (which are not usually responsible for fatigue and strain) in the form of a process—that is the nerve fiber has many points of contact with the muscle cell. However, the nerve fibers to the extrinsic muscles which are usually responsible for fatigue and strain are attached by means of an "end plate" which form a single point of contact between each nerve cell and muscle cell.

During the first few moments of motionless fixation, the contact at the end plate is good, only a low "voltage" of nervicity being required to pass from nerve to muscle; but as the stimulation continues and the lactic acid accumulates around the end plates, acting not unlike corrosion of any electrical contact, the muscle becomes insulated from the nerve and a higher "voltage" of nervicity is required if the impulse is to reach the contractile substance. The higher potential of nervicity required is obtained by consciously directing a mandatory impulse toward the task at hand. The more conscious one becomes of "concentrating" on fixation, the more he complains of "tired eyes" or "fatigue."

When any cell of the body is caused to function unrelentingly until all its stored-up nourishment is consumed the cell is said to be "exhausted" and ill effects of "strain" increase as the point of exhaustion is approached. When exhaustion of any cell occurs as a result of eye strain, it is obviously brain cell exhaustion, if we accept Sherrington.[33] Crile[34] states that the brain cells exhaust fifty times faster than muscle cells.

It has been shown that lymph is produced in greater quantities, is drained more efficiently, and that the circulation of blood increases, with exercises of the natural functions of an organ.[35] It is therefore obvious that rotation of the eyeball, a natural function, tends towards the production, distribution and elimination of lymph.

One need not be radically optimistic to anticipate great advancement in the success and prosperity of the profession of optometry now that it has facilities for supplying that primitive and alienable rhythmic exercise of the extrinsic ocular muscles which modern civilization denies.

It has long been said that oculo-calesthenics have practically no effect on the muscle tissue, and that the correction of heterophorias is accomplished through the establishment of new brain patterns or synaptic paths rather than through any change in muscle structure. This contention is unquestionably well founded, especially when ocular exercises are limited to the crude, slow vergence or prism exercises of the past.

But with the introduction of the myoculator and kratoculator —a means to incite rhythmical, rapid, and extensive ocular excursion with a minimum of voluntary effort—the above statement must be

somewhat modified. Not only do the proper methods of oculo-calisthenics provide exercise of functions denied by conditions of modern civilization, thereby tending to minimize the deterrent effects of the modern visual demands, but actually do tend to influence the proportions of the muscles themselves, aiding no little in the correction of the grosser anomalies of co-ordination.

It is a matter of common knowledge that muscles which are required to perform rhythmically at high speed, alternately extending and contracting to their fullest extent, tend to become long and supple; while those which are required to exert slow, ponderous efforts of contraction tend to become heavy, short and thick. One has but to think of the race-horse and the draft-horse if an example is needed.

Now, for example, if convergent squint be caused by a constantly maintained convergence to assist accommodation in hyperopia of high degree; or if esophoria be caused by prolonged, daily fixation of near objects, then rapid, rhythmical, full flexing of the eye muscles in extensive excursions will undoubtedly tend to restore the interni to normal dimensions.

Students of physical training recognize that a muscle tends to remain in whatever condition of extension or contraction it happens to be when the stimulus for action is withdrawn. If it be agreed that an adequate stimulus for dextervergence is a conspicuous object moving rapidly from the observer's left to right, then the sudden disappearance of the object in the right field would leave the external rectus of the right eye with a tendency to remain constricted. If the object were visible to both eyes, undoubtedly the same tendency would be left with the internal rectus of the left eye; but there is reason to doubt the extent of the same effect upon the muscles of the left eye IF THE MOVING OBJECT IS NOT VISIBLE TO THE LEFT EYE. Clinical observations indicate that when a moving object appears in the nasal field of the one eye, moves rapidly to and disappears in the extreme temporal field of the same eye; and at the moment of disappearance to the one eye becomes visible in the nasal field of the companion eye, moving rapidly to the temporal field; the eyes following the object tend toward exophoria.

Suppose, for example, a conspicuous object to be moving in a circle in the direction of the hands of a clock; and that an opaque shield obscures the lower half of that circle to the right eye, and another shield obscures the upper half of the left eye. The object will then appear to EACH eye in its nasal field, and disappear in the temporal field.

If it be desired to cause a tendency toward esophoria, either the direction of movement, or the position of the opaque shields must be reversed.

Those familiar with the Myoculator Unit will recognize in the Septum, the Rotary Color Device, and the Hall Alternating Color Attachment (used with the complementary color filters) means of

producing many variations of the above described exercise, all applying the same principle.

Again, in certain cases of alternating convergent squint, there is a nominal error of refraction, and (if it be other than one of the rare cases of "essentially alternating" squint) the difficulty lies in part at least in that the left field is explored with the right eye only and vice versa, so that the external recti have never been called upon to constrict completely. If the externi still retain the power of contraction, a tendency to actually shorten the externi can be produced by occluding first one eye, then the other, and holding the open eye as far as possible toward the outer canthus through the fascination of a moving object in the extreme temporal field.

Furthermore, it must always be remembered that each muscle is a part of the entire group, and that no readjustment of the interocular relations can be accomplished without readjustment of the entire group; so that calisthenics should not be limited to any one muscle or group of muscles, but must include all the muscles of both eyes.

Finally, the eyes are but a part of the whole organism, and when oculo-calisthenics are undertaken, results will be greatly enhanced by encouraging general calisthenics and improvement of the body as a whole.

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CHAPTER 7.

CHRONOLOGY OF VISUAL DEVELOPMENT.

Worth[36] states that the eyes of a new-born infant will momentarily fixate a light flashed into the eye in the dark, although the fixation will be imperfect and will not be binocular, even for a few seconds, until after five or six weeks. Zoethout[37] states that binocular fixation is not established until at least the sixth month.

According to Von Hippel[38] the fovea is not fully developed for several months after birth and Zoethout[39] states that fusion does not make its appearance until near the end of the first year.

Authorities on physiological optics seem well agreed that the faculties of vision appear in approximately the following order:

1. Pupillary constriction to light.
2. Monocular fixation.
3. Concomitance (one eye following the other).
4. Binocular fixation.
5. Form conception.
6. Color conception.
7. Fusion.
8. Perspective sense.

The exact order of appearance may vary slightly according to standard" mean that visual acuity (form conception) diminishes as different observers, but there is obvious agreement in that the motor reactions to *any* light precedes mental interpretation of pattern, intensity, or color of light focused on the retina.

Common knowledge and simple logic surely demonstrates that motion adjustments must precede mental interpretation.

F. Treacher Collins,[40] Zoethout (already cited) and others give tables of indirect acuity which, interpreted in terms of "Snellens the object of regard is moved away from the line of direct vision **approximately as follows:**

Direct visions normal acuity	20/20
Normal acuity 3° from line of direct vision	20/70
" " 5° " " of " "	20/80
" " 10° " " of " "	20/250
" " 20° " " of " "	20/800

Obviously, the eye must be turned to fixate the object of regard before correct interpretation can be had of it; even then, 20/20 vision would not be possible until the ciliary muscle had operated to bring about a sharp focus of the image upon the macula.

Optometrists who have investigated the "fusion powers" of their patients know from experience that such powers increase when

acuity is improved and diminish when the acuity is reduced. It is also well known that retinal images cannot be "fused" if one of them falls outside of a very limited area immediately surrounding the macula.

It is, therefore, an unavoidable conclusion that correct determination of the nature of any given object and its exact position in space—in short "seeing"—is a matter of direct vision, or macula stimulation, *made possible by previously accomplished adjustments of the extrinsic and then the intrinsic ocular muscles.*

If it should be determined in a given case that interpretation of direct macula stimulation was alone at fault—that is to say, if fusion, perspective and direct visual acuity were below normal and *no muscular imbalance of any type could be discovered,* then only would it be proper and correct to proceed in the development and improvement of those higher visual faculties, ignoring completely the more primitive.

But if there be demonstrated esophoria, exophoria, cyclophoria, hyperphoria, hypophoria, convergence excess, convergence insufficiency, sluggish fixation, inaccurate excursion (attempting to follow a fixation object moving through a fixed pattern) "premature presbyopia" or faults of concomitance (one eye following its mate inaccurately when covered) then intensive development of the higher faculties such as fusion, without first correcting these more primitive functions would be like unto building a house upon an insecure foundation, or upon the sands.

When faults of these deeper, more primitive visual faculties are present, and they frequently are, the conscientious builder of comfortable eyes will see to their correction before he builds an elaborate superstructure upon an unsafe foundation. He will follow as nearly as possible the building program of Old Mother Nature. He will first of all determine whether or not each eye turns instantly, easily and accurately to fixation of conspicuous moving objects unexpectedly appearing several degrees away from the line of direct vision while the patient's conscious attention is held "neutral" by a casual conversation. The latter provision—neutral attention—is included because movement to fixation is essentially an innate reflex action observable in the new-born infant long before the infant's mind is capable of conscious attention.[41]

Having improved the most primitive ocular function (fixation) by the proper monocular exercise thereof, the next step would be to determine whether or not each eye were capable of vergence movements to the normal extremes and whether or not the extreme positions could be occupied without undue effort, attention, or discomfort.

Third, concomitance should be investigated and if either eye discloses a reluctance to follow its mate, though covered, that reluctance should be overcome by leading each eye in turn through various movements until, through concurrent experience, either becomes exact in following the other's movements.

To accomplish this, it is necessary to provide a moving fixation object which, though following an uninterrupted path in space, is visible, then invisible, to each eye in turn. The alternation of visibility from one eye to the other must be at intervals of from one second to a fraction of a second, the rate of alternation to be regulated according to the promptness of the fixation response. Such optometric means fortunately are now available. With the establishment of an exact concomitance and equi-efficient fixation, all heterophoria will quite naturally have disappeared. Incidentally, the rapidity of alternate attention when increased sufficiently leads alternating squint and suspenopsia to binocular vision and fusion.

Actual and clinical experience demonstrates the correction of these prior-fusional faculties to be accomplished in the most obvious and simple manner conceivable; that is, by exercise of the most primitive ocular reflex actions, fixation of, and following conspicuous moving objects.

This chapter would not be complete if it closed without reference to the exercise of the smallest muscle bodies within the human eye, which respond to the stimulus of light according to the intensity thereof, as a pure reflex action not under the control of will—the cone myoid.

F. Treacher Collins[42] says:

> "Supposing now the image of a black letter on a white ground, such as we have in our best types, be focused on this delicate mosaic of cones, those upon which the white background is projected will be stimulated and contract, those upon which the black letter fell, not being stimulated, will remain uncontracted. Indeed, it seems likely that if we could examine the outer surface of a retina so stimulated, under sufficient magnification, a reproduction of the letter looked at would be seen raised up and composed of the uncontracted outer limbs of the cones."

Then, as our gaze travels across this printed page, those tiny muscle bodies are constantly extending and contracting according to the pattern of light and dark upon them.

Suppose these "muscles" are sluggish from toxins or inefficient through lack of use because of a long uncorrected error of refraction, Amblyopia! There are, of course, other causes of amblyopia, but the fact remains that many so-called "hopeless" cases of dim vision (amblyopia) have been restored to normal acuity by exercise of the muscles of the retina; the calisthenical movement being stimulated by rapid, rhythmical alternations of light and darkness.

Somewhat slower alternations of light and dark, have brought about relief from photophobia through improvement of pupil reaction; and clinical cases of color blindness now under observation give promise of correction through similar methods. See Chapter 10.

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CHAPTER 8.

METHODS OF CORRECTIVE OPTOMETRY.

This latest and most far reaching development of optometric science which these chapters have been introducing, has been aptly termed "Corrective Optometry" thus distinguishing the service it renders from previous optometric service which was satisfied to provide artificial, mechanical aids to vision, avoiding unpleasant or harmful effects of physical and physiological faults without even attempting to eliminate the fault itself. "Corrective Optometry" aims at the correction of physical and physiologic ocular conditions, to the end that the eyes of humanity shall be made stronger and in less need of mechanical aids to vision.

"Corrective Optometry" provides calisthenical means for the alleviation of ocular distress occasioned by occupational demands upon vision, and through physiologic education adapts the eyes of the average man to the proper performance of highly specialized visual tasks which of necessity accompany the acquirement of skill in any of the vocations constituting modern industrial life. In other words, "Corrective Optometry" is the only branch of ocular science which recognizes that to produce a "skilled workman" involves the adaptation of primitive eyes to modern conditions, and provides means of developing "visual skill" to enhance the production value of "skilled fingers." This entirely virgin field is open to the optometrists who first prepare themselves by special studies of industrial needs, to apply the principles of "Corrective Optometry" in the training of workmen for particular duties.

"Corrective Optometry" will not appeal to those whose lack of vision limits them to the commercial vending of mechanical appliances which so prominently straddle the aristocratic noses of America today—that type of commercialist who has invited the slur: "They sell you glasses whether you need them or not,"—but it does and will appeal to the American public and to the ethically inclined, professional minded optometrist who believes: "He profits most who serves best."

Glasses are, in many many cases, absolutely necessary and they should and will be provided by the practitioner of true "Corrective Optometry," *but not merely because an excuse for prescribing glasses can be discovered.* The optometrist of today who provides glasses only after being convinced that glasses are unavoidable, and seeks first to correct physical and physiological faults by physiological and psychological means is rapidly commanding public attention and respect; and his exceptional service will become the accepted and expected optometric service of tomorrow.

"Corrective Optometry" has created a demand for facilities unknown to the refracting and frame fitting optometrist of yesterday. Ophthalmic glass was and is most certainly a boon to the eyes of humanity, but one should not be so blinded by its virtues as to assume without adequate investigation that light which has not passed through ophthalmic glass is of no virtue in the further development of human sight.

The determinative (diagnostic) value of the most recently developed optometric facilities does not lie in determining the error of refraction, and not entirely in the precise determination of deviation from the normal resting and dynamic positions of the visual axes. The new determinative technique of "Corrective Optometry" purposes to discover those cases wherein the ocular functions may be restored to normal without, or with a minimum of dependence upon ophthalmic crutches. (Perhaps such cases are few in number—perhaps not!) but there is an unquestionably large field in which drugs, surgery and ophthalmic lenses have failed to give comfort and efficiency; and in this field "Corrective Optometry" is at present of greatest value.

The new determinative (diagnostic) technique seeks information never required or even sought by the merely refracting optometrist and its value is therefore not apparent to him.

Perimetry, for example, until now, has been considered of value only in pathological diagnosis. "Corrective Optometry" requires assurance that pathology is not responsible for conditions it seeks to correct, and employs both ophthalmoscopy and perimetry to gain that assurance. But with the development of facilities for exploring color fields, so that perimetry is now available for the average, modern equipped office, there have come, and are coming, discoveries that eccentricities of color fields are guides to physiological faults as well as warnings of pathologic conditions.

The most modern facilities provide a more commanding fixation object and means of controlling and accurately allocating the test objects without relaxing the vigilant observation of the patient's eye which is necessary to insure faithfully preserved test conditions. A projected test target is employed which not only provides purer colors, but being projected at various selected angles from a fixed point relative to the patient's eye, insures that the angle subtended by the target to the patient's eye shall remain approximately the same regardless of the increase of the angle between the line of test and the patient's visual axis. Tangent and meridional scales upon the projecting device, or the test screen, enable the operator to take his readings without turning away from his patient, and an accessible switch enables him to remove the test object from the patient's view while making his notations, so that the patient has no opportunity to inadvertently destroy the value of the test by shifting his gaze from the fixation object to the test object without being discovered in the act. Further, the ease with which a great variety of test objects

may be subsituted one for the other without loss of position or time enables the optometrist to investigate the fields for red, green, blue, white, motion, crude form, and useful acuity practically at one operation.

These investigations disclose indications aiding the optometrist to differentiate between physical and pathologic inhibitives to visual efficiency; functional myologic imbalance and paralysis; toxic interference and functional inefficiency; toxic amblyopia and amblyopia-exanopsia; and peripheral suppression and functional inability. Yet this field of exploration is just opening up to the thinkers in optometric practice!

Having a mechanically operated fixation target that may be caused to move along any selected path within the patient's field of vision enables the optometrist, by observing the patient's eyes in his attempt to faithfully maintain fixation of the moving target, to plot myographs (muscle charts) disclosing inefficient muscle groups as betrayed by the patient's *"vergence phobias."* For example, suppose the fixation target to be describing a perfect circle, the patient under observation is instructed to maintain constant fixation of the target so that his eyes rotate upon a radius of 30°. The normal patient will experience little difficulty in maintaining perfect circular excursions at a speed of one rotation a second, even when his attention is distracted by casual conversation, questions, etc., and will even be able to do sums in mental arithmetic without losing the circle. But patients whose eyes have been subject to occupational abuses, or who have experienced discomfort accompanying certain positions of the eyes, will through their "vergence phobias" betray their inefficient ocular muscles.

The "stenographers' triangle"—and the "linotypists' oblique"—are typical examples of occupational "vergence phobias" that disclose the real cause of ocular discomfort in so many cases that have been condensed as "cranks" and "chronic kickers" by refractionists.

The "presbyope's elipse"—and "heterophoria segments"—demonstrated monocularly are examples of physiologic disorders betrayed by "vergence phobias."

Completely dissociated, movable or moving test objects, made possible through the use of complimentary colors, enable the optometrist to discover, and to record in "variographs" variations in heterophoria that occur according to whether the patient's eyes are fixed straight ahead, both turned to the right, both depressed, etc., etc. It will be a considerable surprise to some optometrists to discover that patients who seem exophoric under the customary directly ahead—"muscle tests" may have exophoria when they turn their eyes to the right, and orthophoria when looking to the left; but such discoveries help explain many failures to provide comfortable prism corrections for constant wear.

Some eyes apparently orthophoric when fixing straight ahead,

actually produce diplopia when turned to fixate some extreme of the normal binocular field. Aviators are required to have single binocular vision through an arc of at least 30° from directly forward, along any meridian. Automobile drivers should be so required, and "Corrective Optometry" offers the only correction of such errors when discovered.

The word "Perspective" is being freely used to cover a broad field. Properly speaking, perspective is the ability to properly ascribe to objects visually encountered, their correct position in space relative to each other; "projection" enables one to visually determine the position of an object in space relative to one's own position. Neither of these abilities depends upon binocular vision entirely because both are possessed to an extent by those who are accustomed to monocular vision only. The determinative (diagnostic) technique of "Corrective Optometry" considers both binocular and monocular perspective and projection, and by means of adjustable, moving, dissociated targets used in conjunction with a fixed object visible to both eyes, determines whether or not and to what degree these abilities are present; and when present, but not to the fullest extent, to determine whether the patient depends upon accommodative effort, "muscle sense," or relative size of retinal images to properly ascribe objects seen to their position in space. The value of such determinations is apparent to the thoughtful, not only in cases of heterophoria and squint, but in deciding whether nausea accompanying certain experiences is due to digestive, oral, or orientation disorders.

Fusion—which is both optometrically and ophthalmologically in danger of becoming confusion—is the ability to recognize the monogeneric quality of simultaneous binocular stimulations arising from a single object of regard. In other words, the correct mental interpretation of two images, one on the retina of each eye. The new determinative technique is not satisfied merely to see how far a pair of eyes will depart from normal relative positions to satisfy an already present desire for that interpretation, but it seeks to discover whether departures from normal binocular relations are due to mental, muscular, neurological or environmental conditions. The determinations described in the foregoing paragraphs are all involved in fusion analysis, and in addition the reaction time to monocular and binocular stimulation must be considered. Monocular dominance for color-form or direction-sense must be discovered if the two eyes are to be brought nearly enough to equal mental recognition to function as a perfect team.

A conspicuous target exposed for a measured interval of time should be located as accurately by one eye as by the other. A small spot of light projected upon a plain wall in a darkened room, is exposed for a second, then turned out. The patient who has been facing the wall (one eye covered, in a monocular comparative test) is then required to describe the object, and to mark the point where

it appeared. Patients with two normal eyes experience little difficulty, and display equal ability with each eye, although the precaution must be taken to change the position, color and form of the target, and to perform the test a number of times. Then, if dominance of one eye is not overwhelming, objects, identical in form but of complimentary colors are exposed for an interval and viewed through plano glass of the same complimentary colors, one before either eye. The normal patient will quickly learn to "fuse" the two objects into one of a color distinctly other than either of the complimentary colors actually used, and this third color should be decidedly more nearly white than either of the others.

An almost infinite variety of incorrect replies are possible, but in actual practice the optometrist has little difficulty in determining whether inaccuracies and slow reactions are due to mental, physical or physiological faults, provided this final determination has been preceded by determinative investigation of each eye.

Retinal function and efficiency may be further investigated by greater attention to such phenomena as the positive and negative after images, and "Bidwells ghost"; such investigations now being practical—rather than merely laboratory—possibilities because of facilities at the disposal of optometrists all contained in compact units, the myoculator and kratoculator.

CHAPTER 9.

CHRONOLOGY OF CORRECTIVE METHODS.

Explanation of the various devices constituting the armamentorium for corrective optometry will be absolutely meaningless to the reader who does not first grasp the essential fact that methods described herein seek to restore and to develop perfectly natural, normal function in their proper sequence; a plan completely ignored by every technique (known to the authors) which employs prisms or stereoscopes in any form.

Optometric literature is abundantly supplied with discussions of stereoscope and prism "exercises." Therefore, this limited article will not include repetitions, although the authors wish to state that the merit of prism and stereoscope training in its proper place is fully recognized and freely admitted.

The most serious criticism of fusion training systems so ably and enthusiastically advanced is not of the systems themselves, but of the too obvious unscientific attitude "this is the only means." One is led to wonder how human eyes ever managed to attain normal development prior to the introduction of prism training only a few years ago.

The following outline must not be misconstrued as methods for "fusion training," but rather methods for the development of those more primitive and more essential functions which precede normal, natural fusion and make it possible.

The first evidences of ocular normality in the human infant are the pupillary reflex and a conjugate upward movement of both eyes and the upper lids.

The second appearing evidence of visual normality in the human infant is the tendency of each eye as a separate unit to fixate conspicuous, and especially, moving objects not too far removed from the line of direct vision. The only dispute between internationally recognized physio-psychological authorities concerning this function is whether it be an inate or an acquired reflex. It appears during the first five weeks of life.

In many cases of squint and amblyopia, this most primitive function is either totally absent in the subnormal eye, or, if present, is far from normally prompt and accurate when the stimulus to fixation appears in the field opposite the abnormal resting position. For example, in a case of convergent squint of the right eye, fixation of objects in the temporal field is usually inaccurate, or visibly slower than fixation of objects in the nasal field. Therefore, in all such cases, the new corrective optometry which we advocate proceeds first of

all to develop normal monocular fixation-reflex. The means employed being an alternately visible and invisible, rhythmically moving, conspicuous object, such as a light in a darkened room. Monocular fixation training is, of course, continued to encourage normal development of the connate function, the ability to follow and maintain fixation of moving objects through all normal ocular excursions. Such fixation should occur and be maintained even when the patient's attention is focused upon some other than the visual sense; for example, even when engaged in conversation. Upon careful investigation, it will be found that surprising numbers of modern eyes fail in this most primitive function in that attention must be focused upon the visual act for its proper performance, and fixation becomes very inaccurate when attention is diverted by conversation.

In infancy nature provides that whatever moving object entices one eye to fixation an excursion is visible as well in the companion eye. The normal child never has one eye open and the other closed. The ability to "wink one eye" is an enviable accomplishment even to the six-year-old youngster. Obviously, then, both of a pair of normal human eyes are led by identical individual experiences through parallel excursions during the first years of normal life. Being led independently through parallel paths leads to the habit of concomitance. Concomitance usually makes its appearance not later than the third month of life, and can then be demonstrated by observing the action of one eye behind an opaque covering, while the companion eye is led through a series of excursions by a moving fixation object.

One may readily conceive of a wide variety of monocular inhibitives, such as ametropia, injury, or pathology, which by interrupting for a time the parallelism of synergistic ocular experience may reasonably be held responsible for imperfect concomitance. In other words, the eye receiving the greater experience in the function of fixation and excursion becomes the dominant eye, while the less experienced eye becomes the "floating eye."

When discovered ocular abnormalities are found to include imperfect concomitance in certain or all excursions (a not uncommon circumstance), corrective optometry seeks to reestablish normal concomitance as the second step in development. The purpose is to lead the eyes independently through parallel excursions. The means employed being a rhythmically moving, projected fixation target which, though following constantly a geometrically exact path, is visible to but one eye at a time. Each eye in turn is led a little distance along this path, the "lead" being constantly (rhythmically or irregularly, as desired) shifted from one eye to the other, so that as soon as equal monocular efficiency in the first described fixation reflex is established, the two eyes are, in effect, led through exactly parallel excursions until the normal habit of parallel concomitance is acquired. Complete success, of course, means that strabismus or heterophoria cease to exist. No matter which way or to what angle the eyes are

turned, when the case is corrected, they remain parallel even when dissociated or when one is occluded.

The means of securing alternate visibility are so many that an almost infinite variety of effects may be provided. Variety is of inestimable value in securing continued cooperation through avoiding boredom. The various means employed fall into two general groups. The first consists of arrangements of opaque obstacles which occlude first one eye then the other as the pair move through selected excursions. The second group employs complementary colors. The most satisfactory colors for the purpose being the so-called "signal green" and its compliment "signal red." The patient is required to view the moving target through plano "lenses"—"signal red" before one eye and "signal green" before the other. The projected fixation target, by means of ingenious mechanical and optical devices is caused to change from "red" to "green" at the will of the operator; at fixed rhythmical intervals, or at random irregularity. Or, the fixation figure may be doubled by the projection of duplicate forms, one being "red" the other "green."

The color filters before the patient's eyes transmit opposite portions of the spectra. The "green" transmits the shorter, the "red" transmits the longer wave lengths only. Even a single white target is so presented to each eye when seen through these "scopes" that each eye may be considered as following a separate traget, one "red," the other "green," although the two apparent objects occupy almost exactly the same position in space. Because red is least refrangible, it usually appears to be nearer the observer than the green as a result of greater accommodative effort required to focus it upon the retina; and also because of the greater intensity of red light due to its greater penetrating power.

Fusion of "signal red" and "signal green" is an oculo-mental accomplishment superior to normal fusion because there is no normal circumstance under which one eye receives only the one part of the spectra while the companion eye receives only the opposite portion. So that when fusion of signal red and signal green is once established, normal, natural fusion presents few difficulties.

If repetition be permitted for the sake of emphasis, the foregoing principles do not develop fusion, but develop the neural mechanism below the thalmus so that the object of regard is simultaneously imaged upon the two maculae, permitting the cuneus to receive normal, geometrically matched impressions before awareness of form is awakened. Inasmuch as normal fusion is naturally the correct interpretation of already geometrically matched images, the matching having previously been accomplished by normal, equi-efficient monocular fixation and normal concomitance, it is not surprising that normal fusion more often follows restoration of the more primitive functions of coordination, than restoration of normal coordination follows super-normal stimulation of the fusion faculty.

Space will not permit the discussion of details differentiating between the corrective technique for esophoria as compared to exophoria, divergent and convergent, squint, etc., but viewed in the light of better understanding each individual case will fairly shout its need to the conscientious, properly equipped practitioner of modern corrective optometry. The idiosyncrasies of personality encountered can be solved only by experience and genuine professional interest.

The important fact to be remembered is that Nature develops a normal pair of eyes by establishing orthophoria *before* fusion is acquired. Optometry can follow no better authority than Nature when undertaking the same work. In fact, Nature alone can correct her own mistakes. All the optometrist can do is to assist. One readily recognizes the advisability of assisting the development of functions in their natural order rather than in reverse sequence.

The following outline of correction of an hypothetical case of heterophoria or heterotropia is presented as concrete expression of the principles just expounded, and it is hoped that the redundance will be excused for the sake of emphasis:

(CASE:—Any case in which it has been shown by the customary tests that normal coordination does not exist.)

(1) If errors of refraction exist, especially anti- or anisometropia, a correction should be provided and worn at least throughout corrective training.

(2) If after ametropic correction with lenses, acuity is found to be below normal in either eye or both, it should be improved as much as possible. (The next chapter will be devoted to this step.)

(3) If fixation does not promptly follow the appearance of conspicuous objects in any part of the visible field, especially in the field opposite the resting position, the fixation response must be developed to the fullest extent possible in each eye separately.

(4) If the sense of location does not coincide with the line of fixation, such coincidence must be established. The test consists of exposing a light in a darkened room for an interval just sufficient to permit accurate fixation, while the patient is standing a step or two from the screen upon which the light appears. The light is then extinguished and the patient is requested to place a finger upon the spot where the light was seen. The training consists of repeating the test, and should be with each eye separately, then both.

(5) If either eye is in any degree reluctant to make excursions into any part of the visible field, the reluctance should be overcome.

(6) If either eye tends either to race ahead, or to fall behind the actual movement of a fixation target, the tendency should be corrected by monocular training.

(7) If either or both eyes tend to avoid excursions when attention wanders from the fixation act, the tendency must be overcome by training if possible; avoided by providing rhythm of movement or

position of inhibitives; or defeated by constant watchfulness of the attendant in charge of the training.

(8) After each eye separately is capable of functioning to the fullest of efficiency in every respect, mechanical interruptions, or the alternate colored target with the complementary colored "scopes" should be employed to lead the dissociated eyes through parallel excursions until orthophoria is established.

(9) After orthophoria has been established, or at least every other means has been employed in the attempt, the fusion faculty should (if then necessary) be developed and employed.

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CHAPTER 10.

AMBLYOPIA.

When in the course of a regular optometric examination, the visual acuity of an eye is found to be below the accepted standard, after the error of refraction has been corrected with proper lenses, the condition is described as "Amblyopia."

When no pathologic condition can be held responsible for the dimness of vision, and especially if the eye has for some time had an uncorrected error of refraction, the condition is described as "Amblyopia-Exanopsia."

Literally, the name means "dim vision from disuse"—an eye that has never learned to see acutely or else has "forgotten how." In either case, the condition is considered to be acquired.

Worth[44] expresses the opinion that congenital amblyopia is very seldom met with. He further states that amblyopia is a true loss of vision, not a failure of the function to develop, and that it is acquired before the sixth year.

It has been frequently erroneously stated that an amblyopic-exanopsic eye cannot be restored to normal visual acuity after the patient has passed fourteen years of age. The only reason advanced is that in an older patient, the progress of restoration is so slow that the patient's cooperation cannot be secured and maintained for a sufficient length of time. Therefore, we believe optometry is to be congratulated on having developed a technique which not only shortens the development period in children, but is equally effective in much older cases and has been frequently reported successful with patients well along toward the sunset of life.

The characteristics of amblyopia-exanopsia, which must be borne in mind if the condition is to be successfully corrected, are:

First, unlike other forms of vision failure, it seldom involves more than central or para-central vision; acuity in the extra macula areas remain normal and in some cases even above normal. (See table of normal indirect acuity given in Chapter 7.)

Second, amblyopia-exanopsia differs from toxic amblyopia (dim vision, due to pathologic disturbances) in that the fundus is not visibly affected, whereas pathology sufficient to affect the vision always disturbs the normal color fields and generally leaves some visible trace upon the fundus discernible through a careful ophthalmoscopic examination.

Third, acquired amblyopia may be of any degree, gradually growing worse until even total blindness of the central area may result. Whereas, loss of vision in pathological conditions are usually much

more rapid, while in congenital amblyopia there is practically no change either for better or for worse.

A record of normal acuity assumes:

First, that an image has been properly focused upon the macula.

Second, that the retinal elements have responded to adequate stimuli in a normal manner.

Third, that as a result of the cell response, impulses have been transmitted to the occipital cortex, the cuneus particularly.

Fourth, that the patient's previous experience and intelligence permit him to describe correctly the conception gained.

Inasmuch as this is being addressed to optometry, it may be assumed that the first factor, a sharp image upon the macula, is assured; and it must be assumed that we have in consultation a patient of sufficient intelligence to correctly describe visual impressions properly received, although in extreme cases of amblyopia-exanopsia, it sometimes happens that an unquestionably intelligent patient is unable to describe quickly the impressions received through a long dormant eye.

Having determinated by elimination through case history the use of the ophthalmoscope and perimetric explorations, that the case is truly amblyopia-exanopsia and being assured that the proper ametropic correction is in place during the exercise and training, our problem becomes chiefly that of providing normal response of the retinal elements and a possible improvement of the neuron path from the retina to the brain.

The normal response of the retinal elements in form conception is beautifully described by F. Treacher Collins[45] in the following paragraph:

> "If we could examine the outer surface of the retina so stimulated, under sufficient magnification, a reproduction of the letter looked at would be seen raised up and composed of the unretracted outer limbs of the cones."

A few moments' consideration of the above paragraph brings realization that in order to correctly interpret the test letters, it is necessary for certain cones to respond while those immediately adjacent remain unresponsive. That is, if the object of regard be a black line upon a white surface, it would be necessary for the cone on either side of that line to respond without affecting the cones upon which the black line was actually focused.

If we now consider that an uncorrected error leaves the retinal image out of focus so that there can exist no sharply defined lines between light and dark, we realize that the amblyopic-exanopsic eye has never had an opportunity to exercise certain cones while adjacent cones remain at rest.

To the contrary, the cones of the ametropic eye have always been required to move "enmasse," that is, in groups so that when a sharp black and white image is focused upon the amblyopic retina the

cones meet with difficulty similar to that encountered in an attempt to clinch the little finger without affecting the other fingers of the hand.

The first step in developing amblyopia, by the most advanced technique in corrective optometry, is to exercise the cells of the retina by exposing the eye alternately to light and darkness at rhythmically measured intervals, and inasmuch as the complete action of the cone requires something less than 1/5 seconds, any frequency less than five alternations of light and dark per second, especially if the light be of sufficient intensity and the darkness practically complete, stimulates full action of the retinal cells.

There are at present three principles which may be adapted to this form of stimulation.

In one instance, a beam of light is projected toward the patient's eye from a distance depending upon the patient's sensitiveness to light. The light is then caused to move across the patient's eye so that the eye is flooded with light, then left in darkness for equal periods; light and dark alternating with mechanical rhythm. It has been frequently demonstrated that by this simple technique, visual acuity may be improved to a degree in almost every case regardless of the cause of the dim vision.

A step farther in this direction has been taken by providing means of causing well defined images to be exposed in measured contrast to their surroundings, for a measured period of time, and then to disappear; leaving the patient's eyes in the darkness for an equal period. The alternations being repeated with exact rhythm.

The second phase of training, makes use of the usual phenomena that in amblyopia-exanopsia, the peripheral field is not affected. A chart with test figures of various sizes and forms is placed before the patient in a darkened room. A projected light from the myoculator is now caused to move in any selected pattern of motion to and fro across the targets while the patient is attempting to decipher the test letters in the intermittent illumination.

While involving the first described principle, this technique also provides that indirect vision is being constantly stimulated by a moving light (above all things the most difficult to suppress) while attention is being focused upon direct vision. The correct description of the characters being demanded, the patient is forced to attempt suppression of the peripheral field while retaining awareness of the central field; thereby reversing his former habit suppression of direct actuity only, which habit is characteristic of amblyopia-exanopsia. This reversal of effort brings direct and indirect visual attention nearer the normal relative balance.

The next phase of development is directed more definitely toward the improvement of interpretation. It embodies the principle of comparison. Inasmuch as the amblyopic-exanopsic patient usually has one eye with normal acuity, while the companion eye is at fault, by exposing a selected figure first to the good eye then to the bad

eye, the mind is repeatedly presented with a model of that which should be "seen" through the subnormal eye. For example, consider a figure moving from right to left and observed by the patient whose eyes are disassociated by means of a septum. The figure visible to right eye only for an interval, then moves into the field where it is visible to the left eye only for a like period.

Another means employed is a figure, moving or stationary, which changes from red to the complement green, at selected intervals, viewed by the patient while wearing a green light-filter before one eye and a red light-filter before the companion eye. This figure is visible, then invisible, to each eye in turn because the light from it is complementary to first one filter, then the other.

A third means consists of two fixation objects, one for each eye, the eyes being disassociated either by means of a septum or complementary colors, the figures appearing and disappearing at rhythmic intervals.

Most of the earlier methods employed in the development of amblyopic eyes were negative rather than positive. That is, no particular means were employed to improve the "amblyopic" eye except to provide an approximate refractive correction; while the "good" eye was handicapped with a frosted lens, smoked glass, an eye patch or atropine to inhibit normal activity. Only two of the earlier practices are commendable to modern optometry. One is the practice of having the patient transcribe from a suitable text while using the amblyopic eye only; the good eye being covered with an eye patch. Inasmuch as this is essentially home work, it is imperative that the optometrist require his patient to bring the copy to the office and that the patient be required to do sufficient copying to insure attention to the amblyopic eye for an effective period, say, thirty minutes each day.

The other commendable exercise requires the patient to give close attention to a receding target while the good eye is occluded. The usual method employed is to have the patient stand as near as necessary to a suitable chart, the good eye covered, fix attention upon the center of the smallest recognizable letter, and then back slowly away from the chart until recognition of the letter is no longer possible.

Improvement is probably due to the gradual reduction in size of the macular image which has already been properly interpreted; but a very valuable feature of the exercise is that it permits the patient to observe the progress of his own improvement. He is greatly encouraged to find that he "gained a foot yesterday and two feet today" in the distance at which the letters are clearly discernible.

As the amblyopic eye improves, there is a tendency to continue suppression in actual daily use although suppression has been overcome under test conditions.

Excellent exercises for office and home use to overcome this tendency employ the principle of Javel's bar reading test. The patient

is required to read books, newspapers and the like with a narrow obstruction, such as a pencil held about half way between the eyes and the page. "The control bar reading device" described by Wells is excellent for this purpose. It consists of two or three prongs attached to a head band in such that they are suspended between the patient's eyes and the reading matter. Each narrow obstruction so placed before the patient's eyes obscures part of the print to one eye and another part to the companion eye, forcing the patient to give recognition to both eyes in order to read uninterruptedly.

It is not our purpose to present a theory in explanation of color blindness; nor an argument as to whether or not "true color blindness" can be corrected. We wish to make this statement of facts for the benefit of optometry and humanity.

Cases that have been pronounced color blind by medical school examiners, railroad surgeons, and applicants for the army and navy and aviation corps (who were unable to pass color tests) have been provided with normal enjoyment of color vision and the ability to pass all color vision tests now in vogue through the adaptation of myoculator technique*

Those who applied the technique assumed color blindness to be "amblyopia-exanopsia for certain colors." In addition to using different colored projected targets from the myoculator, colored charts were devised to be placed on the screen, and training given much as for amblyopia-exanopsia. A number of cases passed the Ishihara test for color blindness after a course of myoculator training.**

BIBLIOGRAPHY.

[44]C. Worth, "Squint," p. 61.

[45]F. Treacher Collins, "Aboreal Life and the Evolution of the Human Eye," page 54.

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*The report of Dr. Mike Kennedy to the Conference of Myoculator Technicians at the 1928 A. O. A. Convention (Dr. Campaigne, and others).

**Tests for color blindness by Dr. Shinobu Ishihara, Colonel I. J. A. M. C., Professor of Ophthalmology, Imperial University of Tokio. 1924.

CHAPTER 11.

CLINICAL EVIDENCE.

Any discourse on methods employed in the correction of ocular anomalies must of necessity emphasize philosophy rather than means, with the result that practical minded readers are sometimes prone to consider the entire discussion a mere fabrication of theories. The previous chapters of this series of papers on myoculator technic have not mentioned specific cases. This chapter is devoted to analyses of of actual cases, and the principles applied in their correction by practicing optometrists, reported from all sections of America.

Details of devices, means, and methods employed are not herein given, but a complete report of each case referred to, together with the name and address of the doctor reporting it are in the writer's possession. These names may be secured upon application to them if desired.

The cases presented here have been selected as fair examples of correct principles, aptly applied. That some of the results set forth are unusual in the experience of the average optometrist is not denied. Some of the cases are in themselves unusual, but it is to the credit of the profession that doctors of optometry have correctly and successfully determined and applied the proper corrective measures. Considering the cases which are more commonly encountered in optometric practice, results which may seem exceptional to many readers are not so considered by those who have become familiar through practice with the methods described in our previous chapters.

For the reader's convenience in study, the cases are presented in under the name of the anomaly which each typifies.

Case 1. Amblyopia exanopsia and Esotropia in a Child

Patient—"P. G."—Age 7.
Old Rx O. D. plus 3.00 D. Sph. ⊃ plus 1.25 D. Cyl. axis 100.
O. S. plus 3.00 D. Sph.
Acuity with old Rx (worn two years) O. D. 20/200, O. S. 20/20.
New Rx O. D. plus 3.75 D. Sph. ⊃ plus 2.00 D. Cyl. axis 90.
O. S. plus 4.00 D. Sph. ⊃ plus 0.50 D. Cyl. axis 75.
Acuity with new Rx O. D. 20/200, O. S. 20/20.
Convergent strabismus of O. D. 45°.
Fixation with O. D. could not be maintained.

Treatment—One week of daily treatment consisting of simultaneous stimulation of direct and indirect vision; and in fixating and orienting a rhythmically moving target, left eye occluded. Result—fixation maintained, orientation accurate, acuity O. D. 20/50.

Second week (no especial attention paid amblyopic eye) fixation

target rhythmically moving to demand full vergence movements in all directions, visible to each eye in turn at rhythmic intervals (to break suppression of O. D. with O. S. open) until diplopia was possible; then, 45 prism diopters base-out (during training only) to prove fusion possible.

Third week (no especial attention paid amblopic eye during first of week). Each eye given a target to follow which was invisible to the companion eye, both targets moving rhythmically through same excursions, until orthophoria was established; then eight prism diopters base-in used during exercises only until exophoria appeared. Patient now urged to fuse.—Acuity of O. D. now 20/40.

Fourth week—Resumed stimulation of indirect vision with rhythmically moving target while attention was held voluntairly to direct vision. Results—O. D. 20/40 plus. Orthophoria constant. Fusion good.

Fifth week. Treatment same as of third week. Results—Orthophoria. Fusion normal. Acuity 20/20 O. D. and O. S.—(Dr. B. E. K.)

[Note:—The principle of rhythmical alternations of light and darkness was not specifically applied in this case. Compare results to those of Case 2.]

Case 2. Amblyopia exanopsia in Youth

Patient—"C. N."—Age 20.

Old Rx O. D. plus 0.75 D. Sph.

O. S. plus 3.25 D. Sph. ⊃ plus 0.75 D. Cyl. axis 180.

Worn three years, checked within a year by doctor reporting case.

New Rx O. D. plus 0.50 D. Sph.

O. S. plus 3.25 D. Sph. ⊃ plus 0.75 D. Cyl. axis 180.

Acuity with old Rx O. D. 20/20—O. S. 20/100.

Acuity with new Rx O. D. 20/15—O. S. 20/100.

First day of treatment (two periods daily—morning and afternoon, 15 minutes each, alternate light and darkness combined with stimulation of indirect vision with rhythmically moving light while attention was voluntarily held to direct vision. Result—acuity O. D. 20/15; O. S. 20/40.

Second day—Same corrective principles applied, giving acuity O. D. 20/15; O. S. 20/30.

Third day—Same as above, with addition of full vergence movements (following moving fixation targets, visible first to one eye then the other). Giving acuity O. D. 20/15; O. S. 20/20.

Fourth day—Same exercise as day before.—O. D. 20/15; O. S. 20/15.—(Dr. O. M. M.)

Case 3. Post Operative Convergent Strabismus With Amblyopia exanopsia

Patient—"A. H."

Convergent strabismus 30° O. S. Straightened once by double operation. Stayed straight six months, then turned in again.

Worn glasses 10 years.

Present Rx O. D. plus 3.00 D. Sph. ⊃ plus 0.50 D. Cyl. axis 90.
O. S. plus 4.00 D. Sph. ⊃ plus 2.00 D. Cyl. axis 90.

Acuity with Rx O. D. 20/30; O. S. 20/100.

Treatment: 20 minutes daily.

First ten days: O. D. occluded. Alternate light and darkness to O. S. only. Full excursions of O. S. following rhythmically moving target in all directions. Result—acuity O. D. 20/30; O. S. 20/60.

Second 10 days. Each eye given a target invisible to the other, both targets moving through same excursions. Results—acuity O. D. 20/30; O. S. 20/30; orthophoria and fusion good. Positive reserve 20/16. Negative reserve 26/18.—(Dr. R. M. H.)

Case 4. Partial Atrophy of Optic Nerve With Divergent Squint of 40°

Patient—"B. L."—Age 18.

Accident at age of 3 caused paralysis of right side and deviation of O. D., also damage to retina of each eye, probably a retinal detachment.

Old Rx O. D. plano.
O. S. plus 0.25 D. Sph. ⊃ plus 0.50 D. Cyl. axis 90.

New Rx O. D. (impossible to determine).
O. S. plus 0.75 D. Sph. ⊃ plus 0.50 D. Cyl. axis 90.

Acuity O. D. 20/300; O. S. 20/25.

Treatment: Rhythmic alternation of light and darkness (O. S. occluded) 10 minutes daily. Also attempts to develop fixation and orientation by means of rhythmically moving, appearing and disappearing target. Acuity after 30 days with temporary Rx (approximating final Rx) O. D. 20/200; O. S. 20/25.

Second thirty days, each eye given target invisible to the other, both targets moving through identical excursions. Results—Final Rx O. D. plus 2.00 D. Sph. ⊃ plus 0.75 D. Cyl. axis 90; O. S. plus 0.75 D. Sph. ⊃ plus 0.50 D. Cyl. axis 90. Acuity O. D. 20/100; O. S. 20/25 with orthophoria.—(Dr. W. D. R.)

Case 5. Pseudo Myopia and Esophoria

Patient—"J. C."—Age 22.

Old Rx. minus 2.75 D. Sph. O. U. used 2 years.

New Rx (indicated) —4.00 D. Sph. O. U.

5 diopters esophoria at 20 feet, 2 diopters esophoria at 16 inches, with and without Rx. Fusion poor.

Treatment 3 times weekly. Twelve periods consisting of full vergence movements in fixation of a rhythmically moving target. Results—Rx reduced to —2.75 D. Sph. O. U., giving an acuity of O. D. or O. S. 20/20. Esophoria gone.—(Dr. C. H. J.)

[Note:—Although the diagnosis of progressive myopia would be disputed in this case, many similar cases have been so called, and treated as such by over correcting the myopia.]

Case 6. Myopia With Exophoria and Presbyopia

Patient—"R. N."—Age 51.
Old Rx —1.50 D. Sph. $\supset$ 5 prism diopters, base-in. O. U.
Add O. U., plus 2.00 D. Sph. for reading.
Acuity 20/20 with old Rx.
Exophoria 15 diopters.

Seven treatment periods; each eye following a rhythmically moving target invisible to companion eye, targets moving through parallel excursions. Results—exophoria gone. New Rx —1.00 D. Sph. O. U. with plus 1.75 D. Sph. add. Acuity 20/20.—(Dr. E. D. G.)

Case 7. Myopia in One Eye, Ptosis and Amblyopia

Patient—"T. D."—Age 21.
Old Rx. O. D. plus 0.50 D. Cyl. axis 90.
O. S. plano.
Acuity O. D. 20/20; O. S. barely light perception.
New Rx (retinoscopy) O. D. plus 0.50 D. Cyl. axis 90.
O. S. —5.00 D. Sph.
Acuity O. D. 20/20; O. S. barely light perception.

After five daily periods of alternate light and darkness treatment patient could see and fixate a spot of light in a darkened room. After ten treatment periods in following a rhythmically moving light through all excursions the acuity of vision in O. S. was 20/100. Ten more treatment periods applying same principle enabled the examiner to prescribe O. D. plus 0.50 D. Cyl. axis 90; O. S.—0.50 D. Sph. Acuity of O. S. was 20/80 and the ptosis was gone.—(Dr. C. P. W.)

Case 8. Paresis of Left External Rectus Following "Flu" and Infection in Left Ear

Patient "X" (Male)—Age 17.
Acuity 20/20 each eye.
Rx neglible.

Left eye turned out 95 prism diopters. Could not be turned nearer straight ahead. Head turned to right to avoid diplopia.

Treatment: First week, 5 to 10 minute periods 5 or 6 times daily, right eye occluded, left eye following a rhythmically moving fixation target movement of which was increased as the eye's ability to follow it improved. Deviation reduced to 65 prism diopters.

Second week: Same training daily. Deviation reduced to 45.

Third week: Each eye given moving target invisible to companion eye, both targets moving through parallel excursions. Binocular fixation now maintained except beyond 35° to the left.

Fourth week: Rest. No treatments.

Fifth week: Rhythmically moving target, visible to both eyes part of the time, then to first one eye then the other part of the time; the effect of prism base-in up to 10 prism diopters, then of the same

amounts base-out, being used as an inhibitive to fusion. After third day of fifth week fusion and orthophoria in all vergence positions. —(Dr. B.)

Case 9. Exophoria

Patient—"G. W."—Age 13.

Acuity 20/30 each eye.

Rx (old and new) minus 0.75 D. Sph. ⊃ plus 1.75 D. Cyl. axis 90, O. U.

50 prism diopters of exophoria since 8 years of age.

Patient has been under this doctor's care for several years during which the application of permanent prisms and oculo prism treatments were tried without success.

June 21st began treatments employing principles as described in the foregoing chapters. Daily treatment periods of 15 minutes each.

First two days, rhythmically moving target visible to first one eye, then the other, to avoid suppression. Next seven days, each eye given a target invisible to the companion eye, both targets moving rhythmically through identical excursions. Tenth day of training, exophoria entirely gone, fusion good.—(Dr. B. E.)

Case 10. Esophoria

Patient—"J. W."—Age 5.

Old Rx, ten varieties, none comfortable.

New Rx plus 0.50 D. Sph. O. U.

15 prism diopters esophoria.

Treatment: Fourteen daily treatment periods of ten minutes each; a plus 2.50 D. Sph. O. U. worn during treatment, rhythmically moving fixation target visible first to one eye then to the other. Esophoria, and discomfort entirely gone.—(Dr. F. G.)

Case 11. Left Hyperphoria

Patient—"J. A. G."—Age 64. Head tilted.

Old Rx O. D. plus 0.75 D. Sph., O. S. plus 1.00 D. Sph. ⊃ 12 prism diopters, base down.

Acuity 20/20 (prescribed by doctor reporting).

Treatment: Four times a week for two months. Rhythmically moving target visible first to one eye then the other, followed by target for each eye invisible to companion eye, both targets moving rhythmically through identical excursions. "All muscular imbalance disappeared, head straight, and patient delighted." New Rx plus 1.50 D. Sph. O. U.—(Dr. D. A. M.)

Case 12. Development of Fusion in a Post Operative Case

Patient—"Miss K."—Age 16.

Acuity 20/20 each eye. Rx (old and new) plus 1.00 D. Cyl. axis 90, O. U.

Case taken 8 months after advancement operation on both external rectii. Deviation not visible, but diplopia constant. Three treat-

ment periods, 20 minutes each, following rhythmically moving, fixation target visible first to one eye then to the other stopped complaints of diplopia. Five periods of 15 minutes each following rhythmically moving target visible to both eyes, gradually introducing prism power, developed normal "ductions." Three more treatment periods developed normal steropsis.—(Dr. R. W. H.)

Case 13. A Case of Partial Color Blindness

Patient—"M. S."—Age 10.

Can not pick reds and greens from yarn test.

Acuity 20/100 each eye. Rx plus 1.50 D. Sph., O. U.

Treatments prescribed to improve acuity of vision: Three periods of ten minutes each, rhythmically moving red and green fixation targets visible to first one eye and then the other, resulted in ability to pick out some of the reds. Four more periods as above with an additional ten minutes stimulating indirect vision with moving targets while attention was voluntarily held to direct vision, resulted in ability to pick out all of the reds and some of the greens.

—(Dr. H. E. C.)

[Note:—The unexpected results in this case have led Dr. M. K. to experiment with color blind patients and while he is not yet ready to publish results, he has reported excellent results in three cases.]

Case 14. Nystagmus

Patient—"H. F."—Age 15.

Rx. O. D. plus 0.75 D. Sph. ⊃ plus 0.50 D. Cyl. axis 90.
O. S. plus 1.00 D. Sph. ⊃ plus 1.00 D. Cyl. axis 90.

Acuity 20/20.

Nystagmus following "spells of intestinal hemorrhages" in early childhood.

Three treatment periods (time of each not given) attempting to fixate and follow a slowly, rhythmically moving fixation target; speed and extent of movement increased with ability of eyes to follow; resulted in "no trace of oscillation."—(Dr. H. W. F.)

Case 15. Alternating Divergent Strabismus

Patient—"H. B."—Age 19.

Acuity 20/20 each eye.

Rx plus 0.37 D. Sph., O. U.

Four days' treatment fixation and orientation of moving target, left eye occluded (twenty minutes each day). Five daily periods of the same treatment with right eye occluded. Three fifteen minute periods following a rhythmically moving fixation target visible first to one eye then to the other. Three twenty minute treatment periods, each eye given a target invisible to the companion eye; both targets moving rhythmically through circular excursions. Result: Orthophoria, normal fusion and "ductions."—(Dr. R. W. H.)

Space does not permit individual mention of many types of cases where minor anomalies have been eliminated with great relief to the

patient; nor of cases wherein secondary conditions such as photophobia and premature presbyopia have disappeared under training. Nor of the numerous cases wherein the intelligence, or mental aptitude of the patient has been markedly improved by establishing more normal contact between the mind within and the world without.

The foregoing authentic cases have been cited merely to convince the reader of the practical value of the principles and philosophy expounded in previous chapters.

In no case can anything be accomplished without the patient's cooperation and confidence. Confidence and cooperation are gained or lost during the first interview. No matter how worthy a service may be, its value can not be recognized if that service is poorly presented to the patient. Therefore, this article will close with a discussion of the psychological principles of presenting professional services.

CHAPTER 12.

THE PROFESSIONAL PRACTICE OF OPTOMETRY.

If the foregoing chapters of this herewith concluding series have to any degree aided any optometrist in his struggle to make his services more valuable, they have accomplished their purpose. No matter how valuable one's services may be, that value will not be appreciated if the service is crudely delivered. No successful jeweler would think of delivering a fine diamond wrapped up in a twist of newspaper; for the same obvious reason, professional services should be delivered through the medium of especially constructed instruments rather than crude, obviously "home-made" devices and awkward make-shifts of equipment intended for entirely different purposes. No optometrist will realize his ambition to enjoy a profitable, professional practice until he has learned to present his services in a professional manner.

It is the purpose of this chapter to be of assistance to those interested in that respect.

First of all, it is necessary to reconnoiter the present optometric situation in order to secure an absolutely unprejudiced point of view.

One must realize that optometry has but recently been recognized as a profession by any one, and is by no means recognized as more than a semi-professional business by many "registered optometrists."

What "optometry" *should be,* is a matter of personal opinion, not now at point. How to make a success of professional practice by those who believe "optometry" should be such, is the problem to the solution of which this effort is dedicated.

We venture the following definitions of professional practice and semi-professional-business to the end that the reader may classify his own opinion of what optometry should be according to the distinctions intended by the authors, and profit by the suggestions made, whether or not personal opinions are in accord.

> A professional practice is that personal service, usually in the solution of human equations and problems, from which the practitioner properly expects *adequate remuneration for his individual skill and ability, without profit from articles of merchandise* involved in such services, and not determined by actual time and labor required, but depending entirely upon the value to the patient of the personal skill and ability of the practitioner in the adjustment of such problems as he professes to be in position to understand.
>
> Semi-professional business is that occupation from which

> those therein engaged expect just remuneration for individual skill and ability *in the selection and adaptation of merchandise according to the purchaser's actual need,* and additional *remuneration as fair profit on the merchandise delivered.*

There are, of course, some, using the title "optometrist," who merely sell optical merchandise and specialize in filling ophthalmic prescriptions written by others, and who admittedly place no value upon their individual skill and ability in determining the purchaser's needs; but the majority of such merchants prefer the more correct name "optician."

If the reader will now count the "registered optometrists" in his community, then list separately *those who expect adequate remuneration without profit from merchandise,* he will immediately recognize the justice of the layman's common definition of an optometrist—which is:—"one who sells glasses for a living."

As a rule, when the average rational citizen goes to an optometrist, he expects to buy a pair of glasses; and is prepared to resist buying two pair, just as he is prepared to resist being sold socks when he goes to a haberdasher to buy a shirt. Exceptions to this rule exist only because some optometrists, at least, some of the time, present their professional sides so conspicuously that the merchandise side passes unseen, and in so doing, the door of opportunity to the professional practice of optometry is opened.

A real opportunity, because *people do not want glasses.*

People buy automobiles; Easter hats, and dancing shoes because they *want* them; but people buy glasses only when convinced they *must have them* to assure visual comfort and efficiency.

There is a large and ever increasing number of people who realize, chiefly from experience, that visual comfort and efficiency are derived through the individual skill and ability of the optometrist rather than from the trademarks upon the lens and frame. These people seek the man who depends upon individual optometric skill and ability for a livelihood just as naturally as they go to buy automobiles from the man who sells autos for a living.

Logically, discriminating seekers of professional service prefer the wholly professional optometrist to the semi-professional. Many optometrists claim to be entirely professional because they never prescribe lenses unless lenses are needed, and sell nothing but the highest quality merchandise. Here "professional" is confused with "ethical." Every good merchant believes in his wares, and no successful auto salesman would recommend a delivery truck to a prospect who desires to motor for pleasure.

The professionally aspiring optometrist, having arrived at a logical viewpoint, will not waste time berating and condemning the practice from which professional optometry is being evolved; at least, so long as they be ethical. Rather, he will devote his energies

and investments primarily to the task of making his individual skill and ability superior to that of his contemporaries whose energies and investments are divided between professional efforts and merchandising; and secondly, to devising ways and means of distinguishing his professional individuality; and finally, to the problem of fees.

Distinguishing one's individual skill and ability, after being possessed of such qualties, is accomplished by substituting personality and equipment for merchandise displays; and first person, personal pronuons for the names of instruments, lenses and frames.

The furnishings of the office suite wherein a professional practice is conducted surely reflect and advertise the personality of the doctor. He will not permit his individuality to be submerged by displays of merchandise in common with displays in show cases and cabinets of optical merchants. Neither will he permit the effect of his own carefully chosen and correctly uttered words and phrases to be drowned by the colorful clatter of advertised slogans, names and catch words. In short, the professional optometrist must realize that his clientele *wants* individual skill and ability efficiently delivered, and he will be both polite and politic enough to avoid, in every possible way, confusing their wants with merchandise, or cheapening his skill and ability with make-shift appliances.

The optometrist who does no dispensing has already made his appearance, but as yet, in many communities it may be impractical for the professional optometrist to depend upon another to fill his prescriptions. Nevertheless, he can keep his individual skill and ability in the foreground of the transaction by announcing to the patient, at the conclusion of his examination: "I am now familiar with the condition of your eyes, and I am quite sure I understand your requirements. I will take your case for a fee of such-and-such, and without further charge supply you with the necessary means of assuring your visual comfort and efficiency." In other words, name a fee for *his professional services* and supply the glasses as a part of that service.

The problem is much simplified when the optometrist has become sufficiently cognizant of calisthenical possibilities to conscientiously insist upon a thorough course of orthoptics and observation, requiring perhaps several visits to his office, in every case; after which glasses, if unavoidable, are obviously incidental to the professional service rendered.

The professional optometrist must realize, and it cannot be overemphasized, that his reputation for skill, ability and integrity is the only reason for his professional existence. He must further realize that his reputation thrives upon success and is injured by failures. He must, therefore, erect every possible safeguard for the protection of his professional reputation.

Foremost among such safeguards is the necessity of procuring equipment which insures the best expression of the doctor's skill in

determination, refraction and physiologic correction. Humanity is forever indebted to an optometrist, Dr. Harry L. Fuog, Professor of Phorometry, Los Angeles School of Optometry, for the means of investigating the efficiency of and improving those ocular functions which precede recognition of the object seen. Before his revolutionizing innovation, optometrists and other refractionists began their examinations only *after* the patient's eye was fixed upon the object of regard without recognition of the fact that modern industrial conditions exact their greatest toll of the functions of monocular and binocular fixation, orientation, excursion and co-ordination. From Dr. Fuog's beginning, optometrists in professional practices have developed means of demonstrating and more clearly explaining conditions to their patient; and a systematic techique for the correction of many previously hopeless conditions.

Moreover, the equipment so selected should be adapted in every particular to the use intended. It is no longer necessary or excusable for an optometrist to employ devices for which he must apologize, or which require him to perform ridiculous antics and contortions before the eyes he purports to examine. Neither is it necessary for the modern optometrist to exhaust his own patience and physical energies in directing orthoptic calisthenics, nor to depend upon the rare co-operation necessary if "home exercises" succeed.

Present day optometric instrumentation permits the properly equipped optometrist to investigate and to exercise every ocular function without the sacrifice of professional dignity or prestige.

Another important safeguard is to insist upon sufficient opportunity to examine and study each case. The routine, or preliminary examination must be followed by other appointments until the optometrist, through his study of the case is confident of two equally important factors: First, his own understanding of conditions; and second, the patient's wholehearted co-operation.

Once the optometrist accepts a case, he places his professional reputation in the patient's hands to do with as the patient wills; or worse, subject to the patient's thoughtlessness.

This leads to the question of fees. The fee in every case must be high enough to command the respect of the patient for the optometrist's skill and ability. If the fee named is less than the value of the patient's own time, demanded in co-operation, he will, then or later, seek one whose fees command his respect. On the other hand, the fee named should be within the ability of the patient to pay.

If the patient is able, but unwilling to pay the fee named, it is because he does not sufficiently value either his own visual efficiency or the optometrist's reputation. For either reason, he should not be entrusted with the doctor's reputation, but should be advised to acquaint himself with it, and to return later.

If the patient is willing, but unable to pay the fee named, and is nevertheless permitted to obligate himself beyond his circum-

stances, the debt may, probably will, become an irritant and cause the patient to hold the doctor's reputation too lightly.

Obviously then, the professional investigation of a given case should be continued through a sufficient number of appointments to permit a thorough understanding by the doctor of his patient's circumstances, environment, condition and requirements; and on the other hand, by the patient, of the doctor's methods and aims.

A proper fee is unquestionably a safeguard to professional reputation. Furthermore, inadequate fees will not permit the doctor to secure proper equipment, and will prevent investments both of time and money in the constant pursuit of knowledge demanded by the rapid advancement of the science of optometry. Finally, no man can give his undivided attention to patients' troubles when he has financial worries sapping a great deal of his energy.

Another safeguard is the avoidance of arousing the patient's expectations. It is much better for the patient to realize more than he anticipated instead of less. The professional optometrist will say something like this to the patient who demands assurance of satisfactory results:

> "I am quite sure I know the right thing to do in your case, and how to do my part. However, I can do no more than my best. Much depends on you, and upon circumstances over which I have no control. If you have any serious doubt of my skill, ability and integrity, I would rather not risk my reputation on your case."

In conclusion of this the last chapter, the authors wish to say, as the result of investigations made in every corner of the vast land of optometric opportunity that stretches from the sun's morning bath to its evening plunge, and from Canada's expanses to the balmy tropics, that the professional practice of optometry has today within its grasp, an opportunity greater than that offered any other profession, to render a real and valuable service to humanity. And we hope these chapters encourage active minds to thoroughly investigate achivements of the science of optometry, now being further developed in the professional practice of optometry, which enable the alert and conscientious to promise posterity stronger eyes and greater comfort.

Reprinted from

The American Journal of Optometry
Minneapolis, Minn.